

BBC



MASTERS OF MIND CONTROL
Scary new methods of manipulating your brain



FOCUS

SCIENCE AND TECHNOLOGY TODAY

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Megatsunami

The killer wave that could hit the UK

Secrets of the aurora

Sky glow explained

Ice Age past

Why we should be freezing by now

THE SCIENCE OF ZOMBIES

How chemicals create the living dead

PLUS The terrifying links between monsters and nature

Robot rebellion

Why a future war is inevitable

Life after death

We talk to the man with proof

10 ACCIDENTAL INVENTIONS

Lucky discoveries, from frying pan coatings to Viagra



Q&A

- What's the toughest animal?
- Why do we stretch?
- Will a new species of human evolve?



KEEP FIT, GET FITTER

ON TEST: gadgets that guarantee you a healthy lifestyle





Official fuel consumption figures in mpg (l/100km) for the Ford Kuga range: urban 27.7–44.8 (10.2–6.3), extra urban 44.8–60.1 (6.3–4.7), combined 36.7–53.3 (7.7–5.3). Official CO₂ emissions 179–139g/km. EcoBoost engine is available across all series. Vehicle shown is the Ford Kuga Titanium X in Ginger Ale at extra charge with Appearance Pack (option) and 19" 5-spoke alloy wheels (option).



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WELCOME TO FOCUS



THE SCARIEST MOVIE monsters are usually the ones you don't see. Creaking floorboards and weird footprints send your imagination into overdrive. But how much scarier must monsters have been when stories spread by word of mouth? A lot of embellishment went on, no doubt, but did the monsters of legend have their roots in science? Matt Kaplan heads into the woods on p38.

From fictional scares to real ones... a BBC docu-drama this month explores the prospect of a megatsunami so big it'd batter America's east coast and send 10m-high waves crashing into the UK. Bill McGuire battens down the hatches on p68.

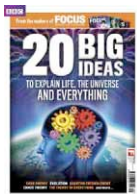
This month also sees the 75th birthday of Teflon and the 50th anniversary of the rather less benign Project MKUltra. Teflon was discovered by chance, and we bring you more happy accidents on p46. Project MKUltra, meanwhile, was a failed attempt by the US military to control minds. But could mind control be possible today? We persuaded author Kathleen Taylor to investigate on p49 (just don't ask us how).

Elsewhere, we test fitness gadgets (p87), try out a new tablet computer (p84) and discover what the Sun has in store as its activity cycle peaks this year (p74).

Until next issue,

Graham

Graham Southorn, Editor



PS Our fantastic new bookazine **20 BIG IDEAS** is on sale now: www.buysubscriptions.com/20bigideas

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APPEARING IN THIS ISSUE...



Matt Kaplan

Matt is a science writer for *National Geographic*, *The Economist*, *Nature* and several other

titles, and the author of the recent book *The Science Of Monsters*. He confronts some of humanity's most ancient fears on p38.



Jon Agar

Jon is a senior lecturer in Science and Technology Studies at University College London,

and the author of books including *Constant Touch*, a history of mobile telephony. He looks at some accidental breakthroughs on p46.



Bill McGuire

Professor of Geophysical and Climate Hazards at University College London, Bill was a

consultant on the upcoming BBC docu-drama *Megatsunami*. Turn to p68 and hold on tight, as Bill outlines a disaster that may be just around the corner.



Kathleen Taylor

Kathleen is an Oxford University researcher in the Department of Physiology,

Anatomy and Genetics. Her latest book is *The Brain Supremacy*. To find out more about mind control, turn to p49. You know you want to...



WANT TO SUBSCRIBE?

Fill in the form on p32 and **save 40 per cent** off the cover price, as well as getting free access to the *Focus* iPad app

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On p32, **Prof Chris Stringer** from the Natural History Museum discusses the origins of mankind

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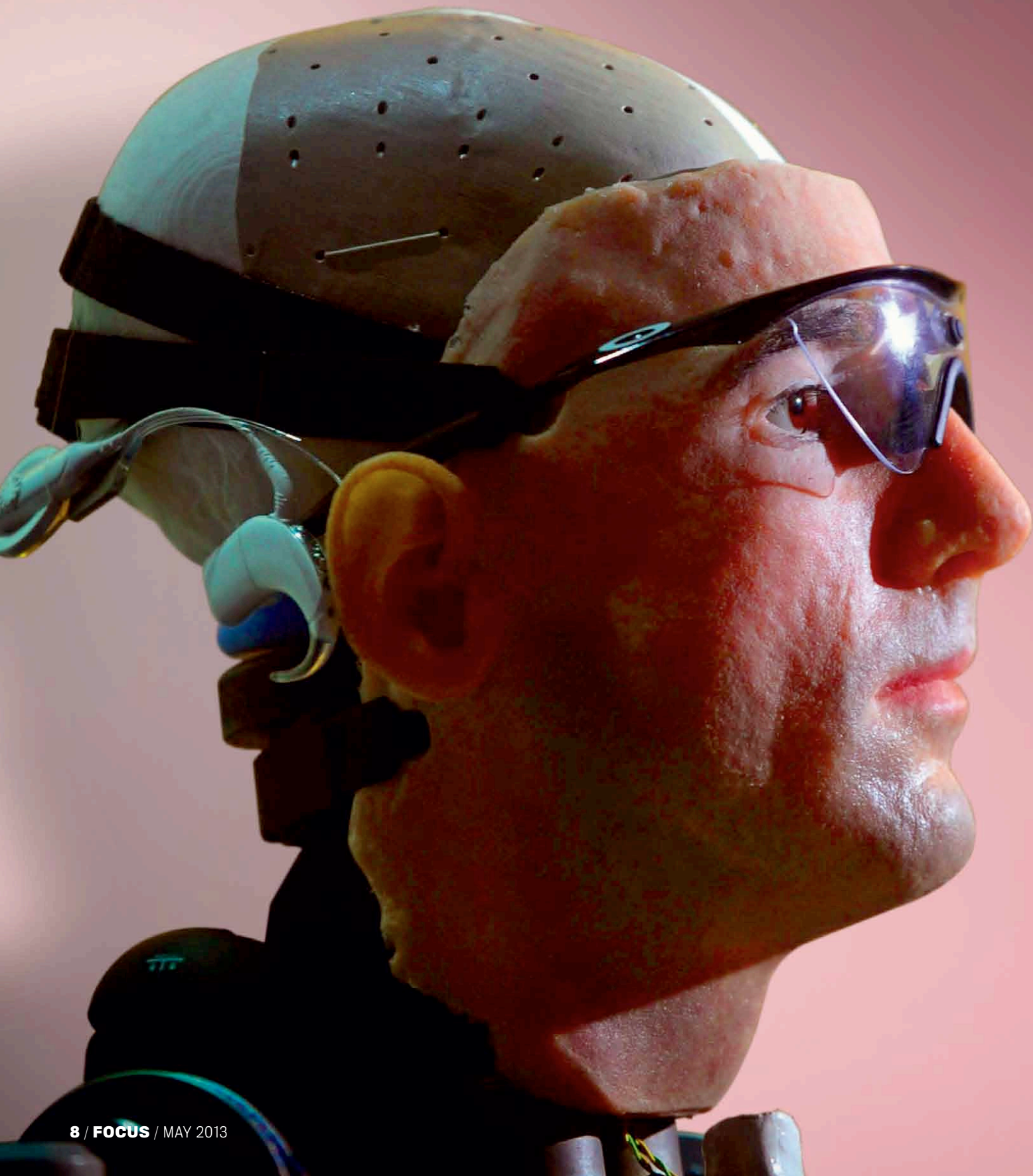
Let *Monaco* make you the star of your own caper movie

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This month's science books

Awe-inspiring images from the world of science

MegaPixel



Face of the future

MEET REX – A collection of cutting-edge prosthetic organs and limbs. Put together for a Channel 4 programme *How To Build A Bionic Man*, he demonstrates the huge strides in research made into replacement body parts in recent years.

“His face is made out of silicone rubber – it’s actually a medical cosmesis that gets used if you lose your face,” says Rich Walker, managing director of the Shadow Robot Company which assembled Rex. “We looked at ‘real’ artificial skin grown in a lab, but it would have rotted within weeks – we couldn’t keep it alive.”

Rex’s face was modelled on that of Dr Bertolt

Meyer, who presented the documentary. As well as bionic arms and legs, Rex boasts a prosthetic heart, lungs, kidney, pancreas, spleen and windpipe, as well as artificial blood, which flows through fake arteries. Cochlear implants allow him to hear, while retinal implants behind his deep brown irises enable him to sense objects. Together, these artificial body parts cost £630,000.

“We rebuilt 60 to 70 per cent of the body using off-the-shelf components,” says Walker. “We’re on the verge of making body parts that are as good as, or better than, those we’ve evolved.”

PHOTO: CAMERA PRESS



MegaPixel

An alien emerges

THIS SINISTER-LOOKING creature is an emerald cockroach wasp crawling out of the remains of a cockroach that has been its home for the past six weeks. Female cockroach wasps (*Ampulex compressa*) lay their eggs on the abdomens of American cockroaches. Immediately after hatching, the larvae burrow their way into the roach's belly. They then use their host as both food source and cradle.

"Cockroaches are genuinely dirty animals; they pick up enormous quantities of microbes from their environment, including pathogens that would kill

the larvae," says Dr Gudrun Herzner, an entomologist at the University of Regensburg in Germany. Research published by Dr Herzner and her team earlier this year shows the wasp has developed an ingenious solution to its insanitary surroundings – it spews a cocktail of antibacterial chemicals from its mouth.

You can watch an emerald cockroach wasp larva disinfecting its host in this video from the research team: <http://bit.ly/Xu2Ycd>. Warning: you'll need a strong stomach.

PHOTO: EMANUELE BIGGI/FLPA



+

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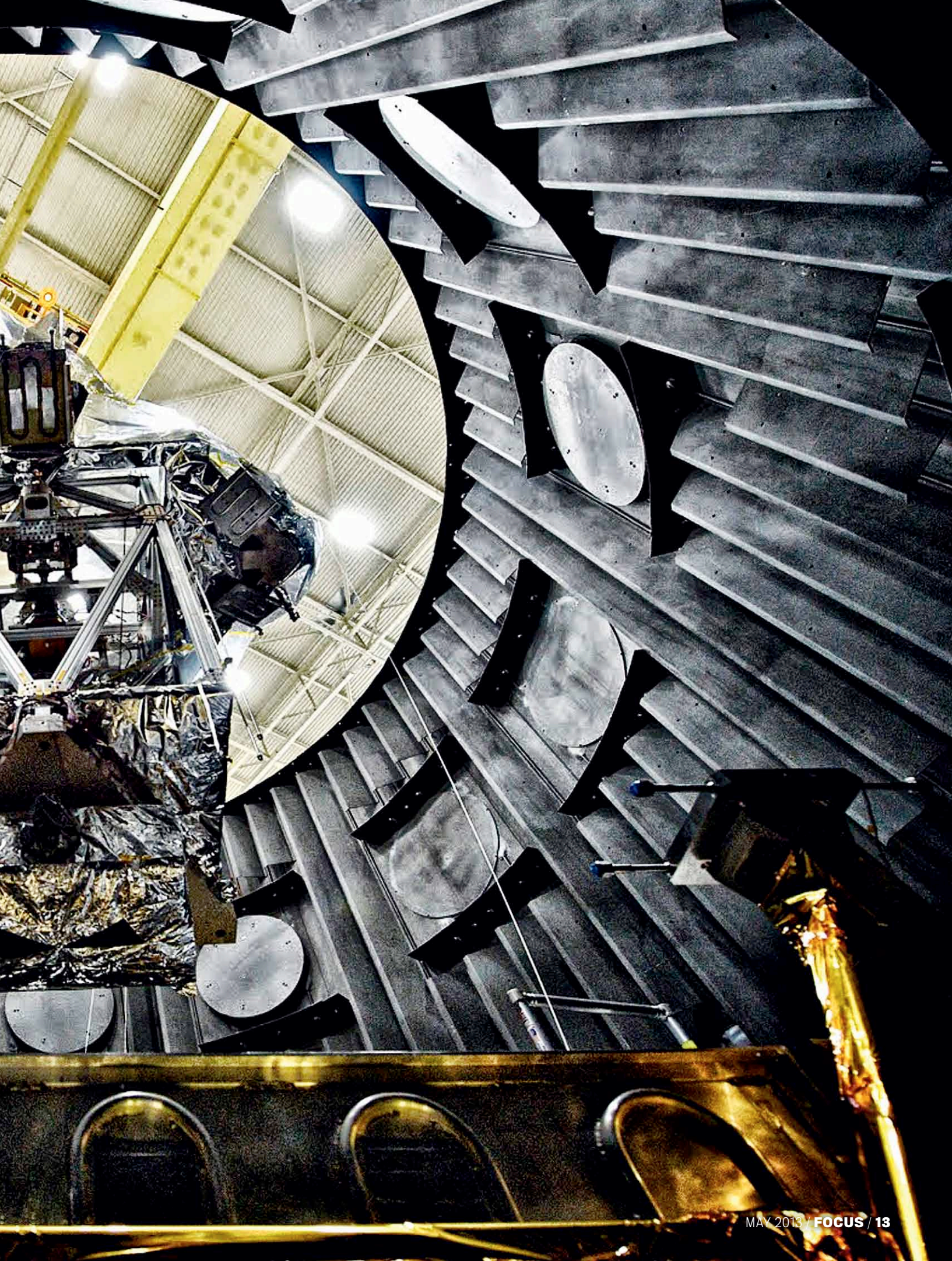
Space on Earth

THIS CHAMBER AT NASA's Goddard Space Flight Center in the US is capable of mimicking space's vacuum and frigid temperature - it's the closest you can get to space on Earth. The instrument being lowered inside is a stand-in for a piece of equipment that will make up part of NASA's new super 'scope - the James Webb Space Telescope (JWST), due to be launched later this decade.

The Optical Telescope Element Simulator generates a light beam similar to the way the space telescope's 'eye' will focus light when it's trained on distant galaxies. The beam will then be used to test the telescope's cameras and spectrographs that will capture and analyse light when the instrument finally reaches space.

The chamber cools any instruments inside to -231°C , similar to the temperature the space telescope will operate at. This will enable NASA engineers to determine whether the telescope's instruments will work accurately in these conditions. "These kinds of tests are vital for space telescopes," says Dr Randy Kimble at NASA. "If there's a problem in space, there's nobody out there to turn a wrench and fix it."

PHOTO: NASA/JPL



REPLY

Your opinions on science, technology and our magazine



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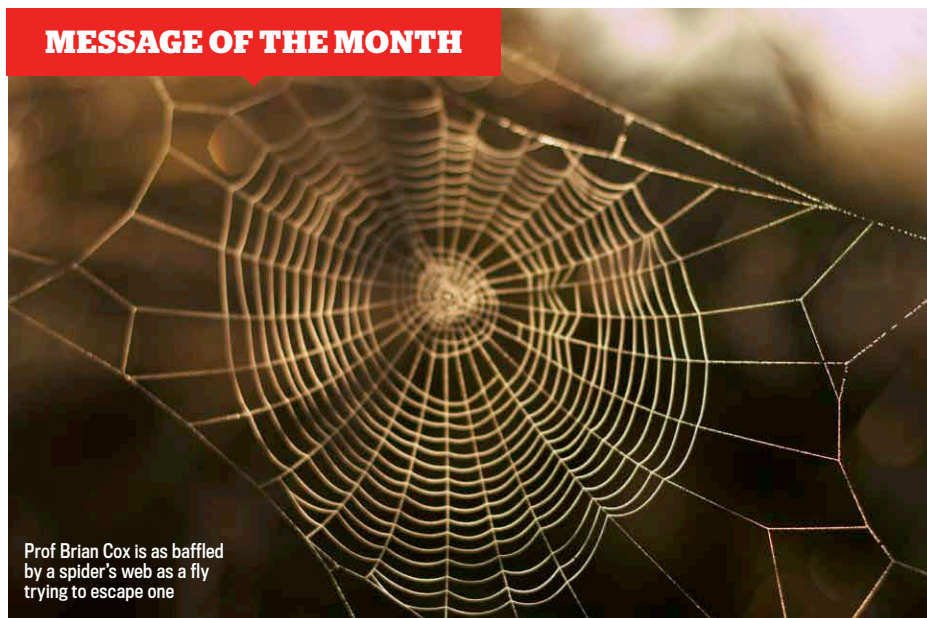
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Letters may be edited for publication

MESSAGE OF THE MONTH



Prof Brian Cox is as baffled by a spider's web as a fly trying to escape one

Wonders of spiders

The general opinion is that spiders make their webs by first floating a loose filament of web on the breeze until it fastens onto a twig or other object, then building the web from there. I think that is, in most cases, untrue. Witness the huge number of webs that are orientated across the wind and are also attached to advantageous points, permitting the spinning of the optimum web for the location. Both these factors would seem to be of overriding importance for optimising the catching ability of the web, thus increasing the spider's survival chances. I once saw a web about 2ft in diameter, across a pair of open canal lock gates, at right-angles to the wind which had been blowing for some time from the same direction.

In [TV series] *Wonders Of Life*, Prof Cox was showing us a new species of

spider in Madagascar and pointed to the top filament of its web, which had been placed across a wide-open space above water. Prof Cox then said that nobody knows how this was done. He had observed the very thing which first attracted my interest many years ago – the ability of spiders, some quite small, to spin the first web filament across 'impossible' spaces.

Over the years I've seen similar examples in nature and also often in my garage in the absolute absence of even the faintest breath of air, which could have led to the spider floating a filament across the gaps. Clearly, the spiders I saw and the one Prof Cox saw, had a navigational ability which nobody can explain. It might be a fit subject for a PhD!

Roger D Britton

No pants please

Robert Matthews's Inside Science piece on insulation (January, p27) raises important issues. Robert was absolutely right to make the point about compensation, but failed to think it through. Yes, compensation lessens the impact of all kinds of things, but that doesn't mean we shouldn't do them. Insulation is good. People wasting its benefits by sitting around in their underwear is bad. So we need to insulate and educate. It's amazing, for example, how many people don't understand thermostats – they turn them up when the weather's cold. We should tell people the best way to save energy is to put another jumper on and turn the thermostat down. The second best way is to put a jumper on the house and leave the thermostat where it is.

Henry Parr

Robert Matthews replies: *Sadly it's not me that hasn't 'thought through' the issue of compensation, but – as the academics mentioned in the piece also point out – governments both here and abroad. Until they factor in the compensation effect, they can't expect to get the return on taxpayer investment in energy efficiency that they're expecting.*

No clones please

If the shock of the new isn't frightening enough, then cloning humans takes things to a whole new level. How will it benefit us: to replace a loved one? All we'll end up with is a look-a-like, perhaps for spare parts. But once we have asset-stripped, who will get the unenviable task of killing what remains and how long would someone have to wait for the organs? In an overpopulated world, do we really need more of us? Suppose, as in Mary Shelley's *Frankenstein*, we create a beautiful body but with a disfigured mind?

Given our track record for messing up – and Dolly the sheep had a lot of problems – anything as complex as a human being created by us would surely turn out to be the child of a lesser god.

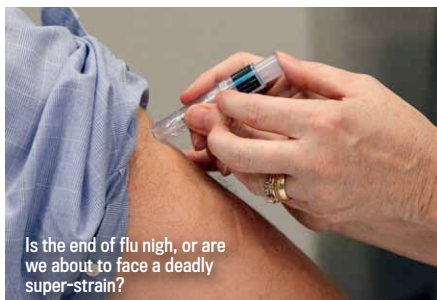
David Storer, Totton



Write in and win!



The writer of next issue's Message of the Month will win a Netgear Centria router, which sells for £199.99. The Centria not only gives you high-performance Wi-Fi, it also doubles as a media server. See www.netgear.co.uk/wndr4700 for more information.



Is the end of flu nigh, or are we about to face a deadly super-strain?

The end of flu

March's fascinating article about 'The end of flu' (March, p62) got me thinking. Scientists are racing to provide us with a 'cure-all' solution to widespread diseases such as the common flu. Virology seems hell-bent on defeating all strains of the bug (one variant, H1N1 killed around 19,000 people worldwide in 2009-2010). However, I wonder if this is the most practical use of our virus-curing abilities? If we do defeat all strains of the bug, will not another killer rise up? Possibly a different strain of the virus, immune to our antibiotics or vaccinations – or something worse. Could preventing all flu viruses leave us open for a new super-bug to evolve? Is the aim of this research to preemptively vaccinate against a new, killer variation of flu, or is it to defeat all present at this current time? And could we be in for something far worse?

David Gwynne, York

Pollen peaks

In the article entitled 'What time of year is worst for allergies?' (March issue, page 81), the information given on timing of pollen allergies is incorrect. Early tree pollens (birch, alder, hazel) will normally peak around March-April, but if the winter is very mild can appear as early as February. Grass pollen season is from May through to mid August with a peak in June-July, although this is variable and dependent on the weather. Other tree pollens are released in early summer and a range of weed pollens in mid-late summer. House dust mite allergy symptoms peak in October-November, when people shut the windows and turn on the central heating. There is a marked difference in timing as one moves north,



It seems that if you're sensitive to pollen, you'll be sneezing for most of the year

so Newcastle is about two weeks behind the south of England.

Dr Gavin Spickett

Gavin pointed us towards this calendar produced by the National Pollen Aerobiology Unit, which reveals the times of year when pollen is released: <http://shar.es/efX76>. – Ed

Simulated Universe

I can't believe this bizarre idea I am reading about (March issue, p43). Look, why not use the Neo 'Matrix' test to see if this Universe is real? The team leaders of the project should find a tall building and throw themselves off it. If everything is a sim, they will bounce. If not: pavement pizza. The huge sums being wasted to build hardware to 'test' this idea could be better spent on developing hot/cold fusion at JET, fully reusable spaceplanes or a space factory seed module to turn asteroids into useful space infrastructure.

E Philpott, South Wirral

The simulated Universe is pretty much a thought experiment, so it probably didn't cost much at all. However, equipment to test whether or not the Universe is a hologram (March, p40) cost \$1 million. – Ed

Oops!

On p67 of the March issue, we said Echinacea Purpurea was a purple cornflower. We should have said Echinacea Purpurea was a Purple Coneflower.

YOUR COMMENTS ON FACEBOOK

On facebook.com/sciencefocus, we asked:

Would you upload your brain to the internet?

Adam Carr No, I'd shock too many people... mind you I do anyway lol

Muge Demir If we can set the privacy I could see it would be a useful tool. There are so many ideas we have in a second that aren't recorded and lost...

John Beirne Forget uploading, I'd rather download info from the internet. "I know kung fu"

Milena Szymaszek Upload my brain to the internet? Oh, that's even worse than a nuclear bomb!

Jane Callister Next step will be the thought police.

FOCUS

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THE FUTURE OF HI-FI

Have your entire music collection at your fingertips with a high-quality end-to-end streaming system from Naim



The digital music revolution has made listening to your favourite music more convenient than ever. A

streaming music system makes your entire music collection available at the touch of a button – and thanks to the Naim range of streaming products, the convenience of streaming music doesn't come at the cost of audio quality. Even better, unlike some of its competitors, Naim can look after your needs at every stage of the streaming journey, from storing your tunes to playing them. Read on to get started on your streaming journey.



Getting connected

The world of streaming audio relies on using an internet connection. Naim recommends a Netgear router or Apple's Airport Express for the best performance. For a wired connection, use a Cat5 network Ethernet cable or add a wireless switch to your router for complete flexibility.



RIP ▼

▼ HDX hard disk player / server



Rediscover your existing collection

The convenience of having your entire CD collection available at the touch of a button is one of the key advantages of a streaming system. Your existing collection, as well as CDs you buy in the future, can easily be made available to stream by 'ripping' them to make digital copies.

For maximum simplicity, you can choose a Naim device that can rip and store your CDs. The HDX and UnitiServe can both make bit-perfect copies of your music using Naim's custom-designed ripping engine, storing music either to their internal 2TB hard drives or to a network-attached storage (NAS) drive.

CATALOGUE ▼

Keep your collection organised

Having thousands of songs at your disposal requires organisation, and Naim's custom-designed Extended Music Database takes care of that for you. The Naim HDX or UnitiServe will categorise every track they rip by name, artist, composer and a host of other searchable criteria, and will even find album artwork to display. You can install Naim's Desktop Client on your computer to search, edit and manage stored music over your home network.



▲ Manage your music using Naim's Desktop Client application

STORE ▼

▼ UnitiServe hard disk player / server



Where to keep your music

For those short on space, the Naim HDX and UnitiServe will store as well as rip your music, with 2TB of space allowing you to store up to 2400 albums in hi-resolution uncompressed audio.

Prefer to keep your music on a NAS drive? Naim's HDX and UnitiServe hard disk players are also available in solid state variants, which purely rip straight to NAS. And if you wish to listen to your music elsewhere in the home, Naim's streaming players will stream direct from your music store, whether it's a Naim server or a NAS drive.



UPGRADE

Take your streaming up a notch

There's always room for improvement and your streaming journey doesn't need to end once you've got your system sorted. The best can always get better and that's exactly what's possible with Naim's simple upgrade path.

For over 25 years Naim has offered users their system with the addition of an external power supply and, more recently, the option of an external DAC, adding more performance while also boosting sound quality.

Now, upgraders will get an even better deal as upgradeable power supplies include Naim's new revolutionary discrete regulator, ensuring you get the best sound quality possible.

BACK UP ▼

Peace of mind

It's always important to keep your music library backed up, and luckily Naim makes this potentially difficult and lengthy process easy and pain-free.

Naim hard disk players like the UnitiServe and HDX offer the option to back up your tracks automatically, by creating duplicate versions of your ripped tracks and storing them on an allocated storage device, such as a connected NAS drive. This can also be used as overflow storage for audiophiles who fill up the HDX and UnitiServe's built-in 2TB hard drive, with the content streamable by any of Naim's network music players or all-in-ones.



CONTROL ▼



◀ n-Stream control app

Complete control however you choose

Naim's free remote apps for iOS devices put the ability to browse and play your music in the palm of your hand.

The Naim n-Stream app works with Naim's range of network players and all-in-one systems, allowing you to flick through album artwork, select music and build playlists. Alternatively, if you have a Naim hard disk player/server, the free n-Serve app will put you in charge of all your stored tunes.

PLAY ▼

Convenience and quality

Whether you prefer the audiophile performance of separates or the convenience of an all-in-one system, Naim has a streaming solution for you. Choose from Naim's NDS, NDX, or ND5 XS network players with matching Naim amplification or the new NAC-N 172 XS streaming preamplifier. Alternatively a SuperUniti, new NaimUniti 2, new UnitiLite or UnitiQute will provide all-in-one convenience alongside Naim quality sound. They all support a range of file formats too, including hi-res audio up to 32bit/192kHz.

▼ UnitiQute all-in-one system



▲ The NEW UnitiLite all-in-one system



To find out more about Naim's streaming products and its vision for The Future of Hi-Fi visit www.naimaudio.com/future-of-hi-fi



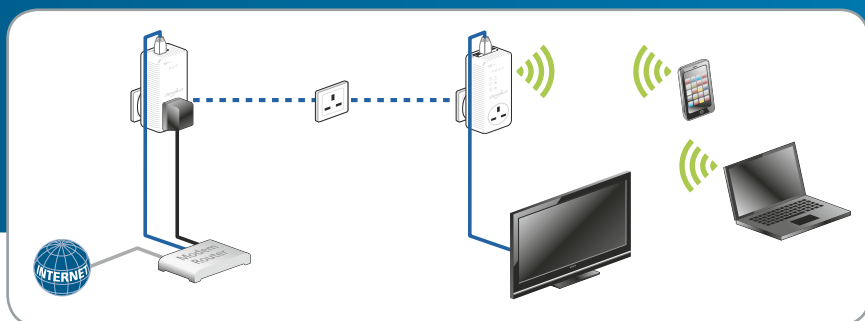
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'Lost continent' discovered lurking beneath the Indian Ocean

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New research reveals that flowers attract bees using electrical signals

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CROWD CONTROL
What can mosh pits teach us about coping with disasters?

THE BIG STORY

Secrets of Russian meteor revealed

Space rock's death throes provide a window into its past

ON 15 FEBRUARY, early morning drivers around the Russian city of Chelyabinsk were startled by the biggest meteor strike in more than 100 years. Appearing literally out of the blue after sunrise, this cosmic missile became a fireball brighter than the Sun before exploding into thousands of fragments over the Urals. Since then, planetary scientists have been studying videos of the space rock's final moments and analysing its remains.

The task of tracing the meteor's final moments was made easier by a network of CCTV cameras

in and around Chelyabinsk, plus footage of the brilliant fireball from the 'dashcams' commonly fitted to Russian cars to record accidents.

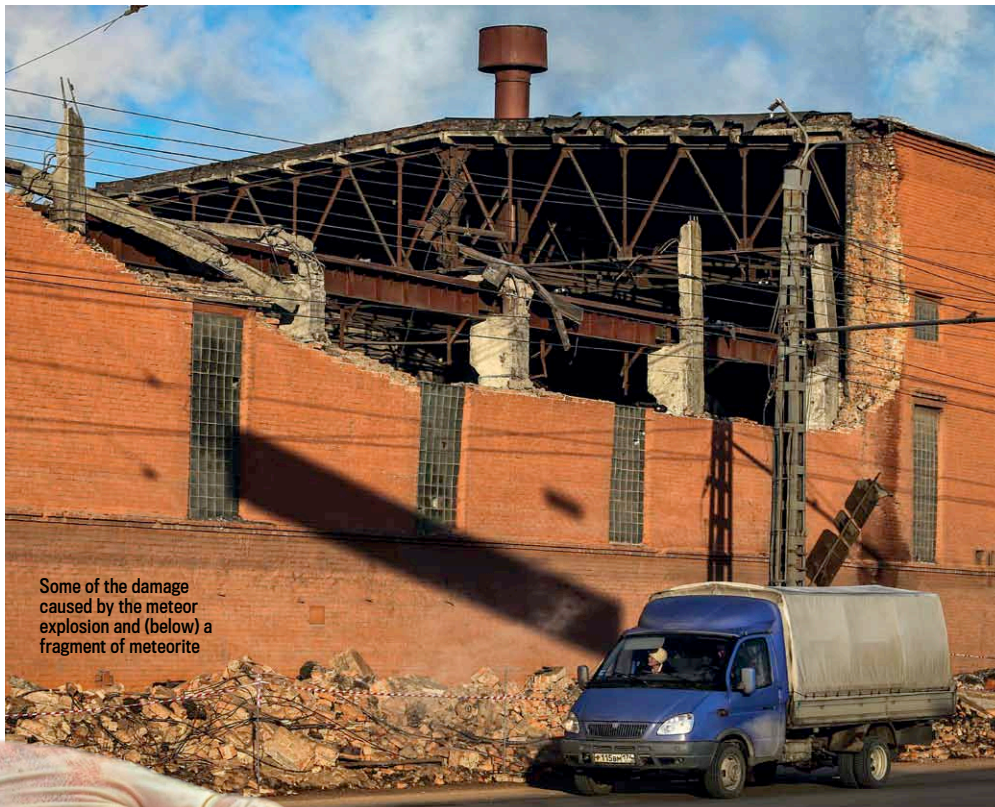
By analysing seven different videos, Dr Pavel Spurný and his team at the Ondřejov Observatory near Prague were able to triangulate key points in the rock's path and from that, calculate the meteor's orbit before it ran into our planet. Spurný says the rock orbited the Sun on an elliptical path that stretched from Venus to the centre of the asteroid belt between Mars and Jupiter.



The largest meteorite fragment landed in frozen Lake Chebarkul



PHOTO: GETTY



Some of the damage caused by the meteor explosion and (below) a fragment of meteorite



“Our main contribution was to determine its atmospheric trajectory,”

Spurný tells *Focus*. “We proved that the main piece landed in Lake Chebarkul and that two or three large fragments and thousands of smaller, coin-size meteorites originated from the two biggest flares.”

Spurný’s analysis also shows the rock first became visible at a height of around 92km above ground before exploding at a height of 32km, 11 seconds later. The resulting shockwave damaged buildings and injured over 1,000 people. As it entered the atmosphere, the rock would have been about

the size of a house and would have weighed in the region of 9,000 tonnes.

Many fragments of this behemoth have been found lying scattered around Lake Chebarkul. Prof Viktor Grokhovsky of Ural Federal University has collected more than 50 pieces himself, and found the asteroid was stony with a little iron, classifying it as a ‘chondrite’. The fragments contain glassy veins that would have been generated by collisions with other asteroid belt objects. This battering is likely to have led to weaknesses within the rock, which resulted in the spectacular explosion in our atmosphere. Rocks that were less flawed might have hit Earth’s surface intact.

Spurný is working to further refine his calculations of the rock’s orbit using more observations. The meteorite chunks will also be analysed in greater detail to reveal what they contain.

PAUL SUTHERLAND



TIMELINE

A history of space rock strikes

65M YRS AGO

A 10km-wide asteroid strikes the Yucatan Peninsula in Mexico, causing mass extinctions including the death of the dinosaurs. The 180km-wide Chicxulub crater it created was discovered in 1978.

48,000 BC

A 300,000-tonne, 50m-wide iron asteroid hits Arizona with the force of 2.5 million tonnes of TNT. It blasts a crater 1km in diameter, known today as Meteor Crater.

1908

An asteroid or small comet explodes over Tunguska in Siberia, flattening millions of trees and stripping others of bark for hundreds of square kilometres.



1947

An iron asteroid falls over the Sikhote-Alin mountains northeast of Vladivostok in eastern Siberia, dumping 70 tonnes of meteorites, the biggest fall ever recorded.

1965

In the last major meteorite fall over the UK, a brilliant fireball showers stones over the Leicestershire village of Barwell on Christmas Eve.

2013

A 17-20m-wide asteroid falls into the sky above Chelyabinsk, Russia. As the rock breaks up in our atmosphere, the explosion has energy equivalent to 90 kilotonnes of TNT, according to NASA’s Jet Propulsion Laboratory.

ANALYSIS

Prof Alan Fitzsimmons



Astrophysics Research Centre, Queen’s University Belfast



WE KNEW THAT airblasts can cause significant damage.

What we now have from Chelyabinsk is first-hand measurements of what that shockwave will do over a populated area. Most such events happen over the ocean but 30 per cent will strike over land. As more and more of the Earth is populated, we will suffer more such effects.

There are probably up to 10 million asteroids of similar size threatening the Earth. We can do little about them unless we have been able to calculate their orbits very accurately by observing them well in advance. With these small ones, that’s always going to be a problem because you need days or weeks of data.

The future looks more rosy because two surveys looking for near-Earth objects – the Catalina Sky Survey and PanSTARRS, which both use ground-based observatories – are getting major upgrades over the next year or two. NASA has also just funded the Atlas (Asteroid Terrestrial-Impact Alert System) project in Hawaii, which will detect small objects on an impact trajectory.

But that won’t help us find asteroids like Chelyabinsk that arrive in daylight from out of the Sun. To find those you’d need satellites watching from a distance, such as near Venus, looking out into the Solar System.



WHAT DO YOU THINK?

Give us your opinion on asteroids at facebook.com/sciencefocus



The island of Mauritius sits where a much larger, much older landmass once lay

GEOLOGY

Lost 'continent' found under Indian Ocean

BELOW THE INDIAN Ocean, a continent has lain hidden for millions of years, but now its presence has been revealed by grains of sand lying on a beach. What's more, geologists believe there could be lots of these 'ghost continents' scattered around the globe waiting to be discovered.

When an international team of geologists analysed sand from the beaches of Mauritius, an island in the Indian Ocean, they found zircon crystals ranging from 660 million to nearly two billion years old. But Mauritius is a much younger, volcanic island – its oldest rocks are no more than 8.9 million years old.

These zircon crystals ('zircons') are also much older than any sea floor crust on the planet, so the researchers suggest the zircons were dragged up from an ancient landmass that once linked India and Madagascar – volcanic activity bringing them to the surface, where they mingled with the island's sands.

To test this idea they looked at maps of the Earth's gravitational field, which reveal the thickness of the Earth's crust. They identified a banana-shaped sliver of unusually thick crust under the Indian Ocean. This crust, they say, could be the remnants of the microcontinent they have named 'Mauritia', which broke apart when India and Madagascar started to go their separate ways 85 million years ago.

"Lots of other oceanic islands could be sitting above drowned microcontinents," says Dr Hans Amundsen, a geologist who runs the Norwegian company Earth and Planetary Exploration Services and who was involved with the research. "The Canary Islands and Madeira in the Atlantic Ocean are two possible candidates. To find out, scientists need to look for old zircons that have survived their travels to the surface," says Amundsen. "I think we're going to find more."

JAMES LLOYD

1 MINUTE EXPERT Spider-Sense suit

What's that?

It's a suit that enables its wearer to sense when a person or object is approaching, just as Spider-Man's 'spider-sense' tingles whenever there's a nearby threat.

How does it work?

Developed by Victor Mateevitsi, a computer science PhD student at the University of Illinois in Chicago, the suit is made up of several pocket-sized modules strapped to the wearer's body. Each module sends out pulses of ultrasound whose reflections are picked up by microphones. By measuring the time taken for the reflections to travel back, the device calculates the distance to the closest object.

A small robotic arm on each module then applies pressure to the wearer's body when it senses something close, with the pressure increasing as the object gets closer. Positioning these devices all over the body can provide the wearer with a 360-degree 'spider-sense'.

What could it be used for?

It could enable a cyclist to detect traffic behind them, or a tourist to avoid pickpockets. Visually impaired people could also 'feel' their way through a room, while using other types of sensor could allow the detection of threats such as radiation.

WHO'S IN THE NEWS?

Dennis Tito

Space tourist and head of the Inspiration Mars Foundation

What did he say?

Tito announced that his newly formed Inspiration Mars Foundation is planning a Mars mission, to launch in January 2018. The mission will make use of an advantageous alignment of planets that will allow a round trip in 501 days. Tito says this is the right moment for a such a mission. "There is no time to lose. Now is the time," he said.

Who is going?

Tito, who made his millions through investments and who was the first private space flight passenger, will not be a crew member for Inspiration Mars. Instead, he's looking for a married couple for the trip. "When you're out that far and the Earth is a tiny blue pinpoint, you're going to need someone to hug," he told Space.com.

Will he pull it off?

Maybe, if he can raise the necessary cash. Tito is putting up the first two years of money himself, but after that Inspiration Mars will need to find backers – although that's not as big an issue as you might think. By not actually landing on the Red Planet, Tito says he can keep the costs comparable to those of a mission to low Earth orbit.





A bee lands on one of Bristol University's electrically charged artificial flowers

Biology

Electric flowers have the power to bring in bees

EVERYONE KNOWS THAT flowers use bright colours and enticing fragrances to attract pollinators – but what's not so widely known is that they also use electrical signals. In fact, nobody knew about this electrical attraction until biologists recently discovered that bumblebees can detect a charge and use it to determine which plant they visit. Charge detection may help bees decide which flowers hold plenty of nectar.

To investigate, biologists at the University of Bristol created artificial flowers, filling some with sucrose and others with quinine, which bees don't feed on. Initially, the bees (buff-tailed bumblebees of the species *Bombus terrestris*) visited the flowers at random. But when a 30 volt field, typical of a 30cm-tall flower, was applied to the artificial plants containing sucrose, the bees detected

the charge from a few centimetres away, and visited the charged flowers 81 per cent of the time.

When a bee visits a flower some of its positive charge transfers to the plant, and further bees transfer more charge. This could show an incoming bee that there's unlikely to be much nectar on offer. "The last thing a flower wants is to attract a bee and then fail to provide nectar," says Professor Daniel Robert, who led the research. "It's a lesson in honest advertising, since bees are good learners and would soon lose interest in such an unrewarding flower."

It's thought the electric charge supplements the other signals flowers use. Exactly how bees detect electrical fields is unknown, but the researchers speculate that the hairy bees bristle up under an electrostatic force.

ANDY RIDGWAY

DIGITAL WORLD

Science on the web

60-SECOND ASTRONOMY

<http://bit.ly/10hPTFA>

Produced by the Open University, these videos each take 60 seconds to tackle a different topic – from the Big Bang to black holes, through exoplanets and dark matter – with a few gags from comedian David Mitchell thrown in.

WHAT IF?

<http://what-if.xkcd.com>

Randall Munroe, author of web comic XKCD, recently branched out into answering questions spanning science, technology and more. The answers can be surprising, but are always interesting and well thought-out.



What If? uses line-drawings and humour to make science easier to get to grips with – and fun

UWINGU

www.uwingu.com

With Uwingu (Swahili for 'sky'), you suggest names for planets around distant stars. The names then enter a database, with the promise that astronomers will pick from them when looking to name an exoplanet. The catch is that you pay \$4.99 for each nomination, which Uwingu says will be used for space research and education.

BD MAPS

www.bd-maps.net/maps/

Plot data about a disease outbreak on a map and you can get an idea of how it is spreading. Get people all over the world to do the same, and you really start to get somewhere. BD Maps does exactly that in an attempt to monitor the spread of *B. dendrobatidis*, a fungal disease that affects frogs and toads, and presents a great opportunity to see real science in practice.

KELLY OAKES



GRAPHIC SCIENCE

Seeing research differently

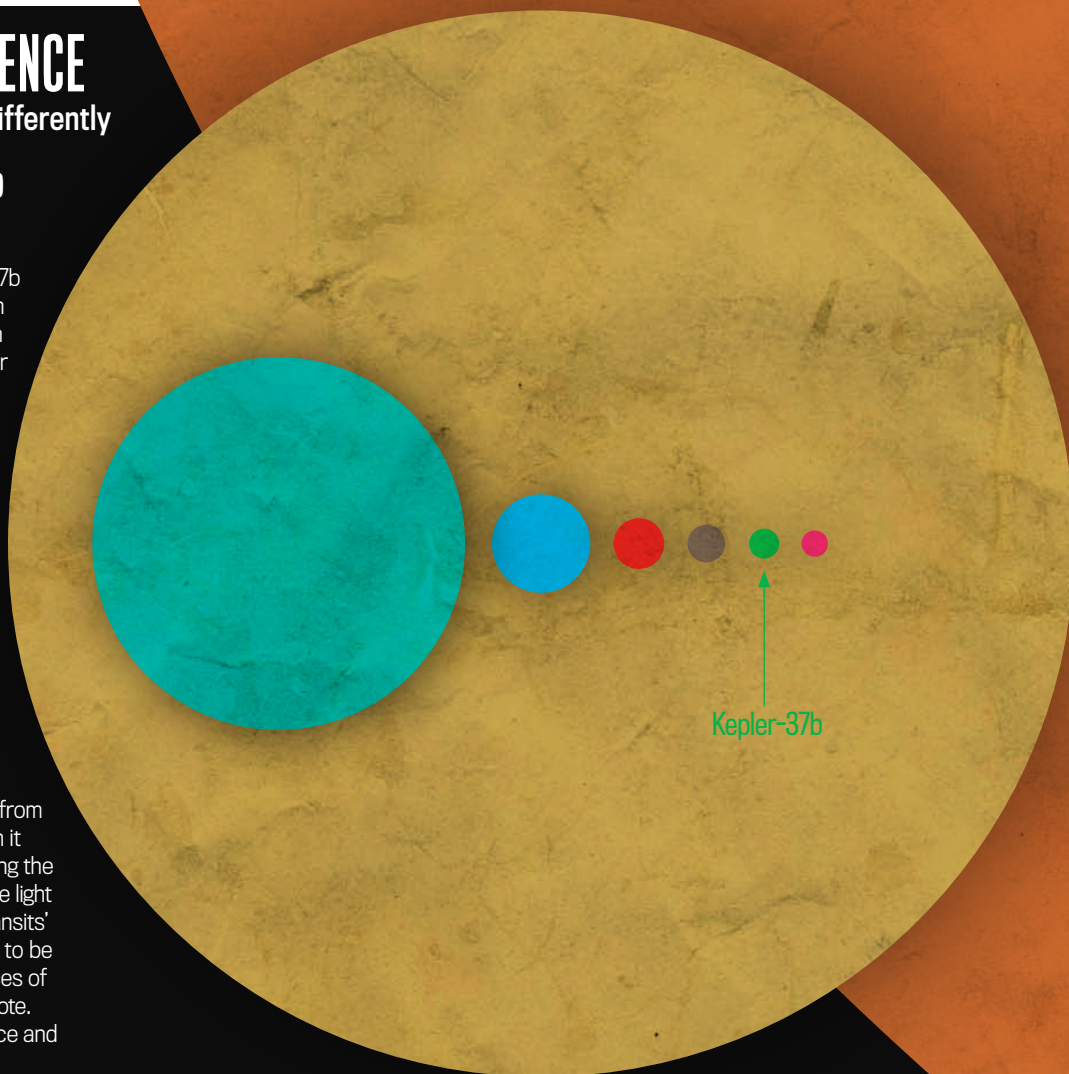
TINY PLANET DISCOVERED

ASTRONOMERS HAVE FOUND a record-breaking planet, Kepler-37b – the smallest planet known. With a diameter only a little larger than our Moon, it's significantly smaller than Mercury, the smallest world in our Solar System. Until very recently, exoplanet hunters were only able to spot planets in other systems that were the size of Neptune or Jupiter. But enhanced techniques mean ever-smaller exoplanets are now being revealed. You can compare its size on the right to that of HAT-P-32b, the largest exoplanet ever discovered.

Kepler-37b, which lies 210 light-years from Earth in the constellation Lyra, was detected using the Kepler space telescope from the drop in light it produces when it passes in front of its star. Knowing the size of the star and how much the light level drops when one of these 'transits' takes place allows a planet's size to be determined. But sadly, the chances of Kepler-37b harbouring life are remote. It's a blistering 400°C on its surface and has no atmosphere.

“ Even Kepler can only detect such a tiny world around the brightest stars it observes. The fact we've discovered Kepler-37b suggests such little planets are common. ”

Dr Jack Lissauer, planetary scientist at NASA's Ames Research Center in California



PLANET DIAMETERS

Neptune: 49,244km
Earth: 12,742km
Mars: 6,778km
Mercury: 4,879km

Kepler-37b: 3,865km
The Moon: 3,474km
Jupiter: 142,984km
HAT-P-32b: 285,236km

10mm =
10,000km
└───┘

NEWS IN BRIEF

Appendix useful after all

• A study of 350 mammal species reveals that the appendix is found in such a diverse range of species it must have evolved independently over 30 times. This suggests that, contrary to previous belief, it *does* actually have purpose. Separate evidence points to it acting as a 'safe house' for beneficial bacteria when illness wipes out microbes elsewhere in the gut.



Appendix: we think it's actually useful now

Red Planet was habitable

• NASA's Curiosity rover has found the best evidence yet that microbes could once have lived on Mars. It analysed a rock sample and found proof that Mars was once a non-acidic environment with water as well as energy-giving minerals. The sample was collected from a veiny rock near an ancient stream bed in an area called Yellowknife Bay.

Picasso's cheap paint

• Picasso used house paint to create his masterpieces. Scientists in Chicago used a device called a hard X-ray nanoprobe to analyse white paint samples from Picasso's paintings as well as old house paints. They found the chemical structure of Picasso's paint matches that of Ripolin, the first commercial house paint.



PATENTLY OBVIOUS

Inventions and discoveries that will change the world with James Lloyd



The pillow that reads your mind

Taking a power nap is a great way to recharge your batteries, but as anyone who's fond of an afternoon snooze will tell you, napping for too long can leave you feeling even groggier than you were before.

Enter Sony's new smart pillow.

An electrode attached to the pillow's surface rests against your head as you sleep, monitoring your brain waves – the rhythms in your neural activity. Different stages of sleep are associated with different brain wave frequencies – REM sleep, the

stage when we dream, is characterised by relatively rapid 'alpha' brain waves, for instance. So the pillow can tell not only when you're sleeping, but also how deeply.

This means the device could be programmed to sound an alarm just after a period of rapid eye movement (REM) sleep, and before you go back into deep sleep, so that you wake up less disorientated.

Patent application number:
US 20130035541

Don't just listen, play along

Have you ever wanted to play along with the music on your MP3 player? Maybe that Lady Gaga track would sound better with a dirty great guitar riff on top, or perhaps you've always thought Beethoven's *Moonlight Sonata* would benefit from a gentle cello accompaniment? Well, fledgling improvisers may soon get their wish thanks to a portable music player patented by Samsung.

The device features a miniature keypad that allows you to jam

along with your favourite tracks, on any one of a number of selectable instruments. In guitar mode, the keys might correspond to the frets on a six-string, while a motion detector would sense the fingers on your other hand as you strum the chords.

With your noodling blasted out through a built-in speaker, though, you'd better make sure you're in a soundproof room before giving it a go... any other Gaga fans on the bus just *might* not appreciate your efforts as much as you do.

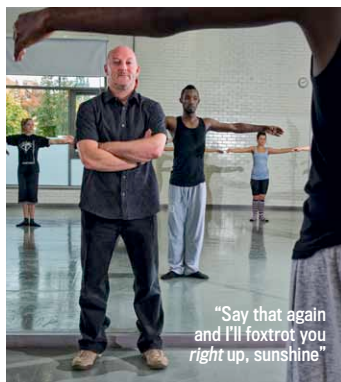
Patent application number:
US 8378202



Touchscreen, clean thyself

As all schoolchildren learn, sticky fingers carry germs! So Microsoft is looking to patent a touchscreen system that'll zap away nasties by shining ultraviolet light onto a transparent film covering the screen. The light travels through the film, killing off bacteria and viruses and disinfecting your fingertips in the process. To avoid overexposure, the system can also switch itself on after you've finished swiping.

Patent application number:
US 20130045132



THEY DID WHAT?!

Blokes bust some moves for science

What did they do?

Male volunteers danced to a Robbie Williams track in a lab at Northumbria University while

their moves were traced using 3D motion-capture. They also had fitness and strength tests.

Why did they do that?

Psychologists were investigating what signals dancing sends out. The dances were rated by other volunteers who watched virtual representations of the dancers, and made predictions about the physical strength of each.

What did they find?

Both female and male observers were able to predict the stronger men from their dancing. It's always been thought any signals given off by men were just aimed at females. But the fact heterosexual male observers were able to pick up on the cues shows that they are also used to assess the physical strength of a potential love rival, say the researchers.



BEAT AN ITCHY SCALP[†]



Joe Hart,
England Goalkeeper



Get instant relief with head & shoulders Itchy Scalp Care shampoo[‡], a new formula with extract of eucalyptus. Now also available in new Itchy Scalp Care 2in1.

*Visible flakes seen at 2nd with regular use. †Itch associated with dandruff.



The submersible approaches one of the vents teeming with life



Ocean exploration

Life reaches new depths around vent

EXPLORING THE DEPTHS of the Caribbean Sea, a robotic submersible has found the deepest set of hydrothermal vents in the world – and life. Nearly 5km beneath the surface, the craft encountered towering chimneys spewing dark water.

The vents lie in the Cayman Trough, a trench lying between Jamaica and the Cayman Islands and formed by the boundary between two tectonic plates. Water released from the vents was recorded at 401°C – some of the hottest on the planet – but it hasn't stopped animals from living nearby.

In water samples collected by ISIS, the remotely operated vehicle run from British research ship James Cook, were strange, otherworldly animals – many of them new to science. They included

anemones, starfish, Cyclops-like shrimp, and a plethora of microbes that harvest energy from the mineral-rich vent exhaust.

This newly discovered set of vents lies close to the 'Beebe' vent field the team visited three years ago. "That you can miss something so large shows how the deep ocean always has surprises to offer," says expedition leader Dr Jon Copley of the University of Southampton.

"If there are more of these vents out there, then they may have more influence on the chemistry of the oceans than people realised," says Copley. "This provides another missing piece in the jigsaw puzzle of how life disperses and evolves in the deep ocean."

Many months of lab work examining the biological bounty now lie ahead.

ZOE CORMIER

Physics

Moshers bounce like molecules

THE LAWS OF physics may be the last thing on their mind when they're bouncing around to heavy metal, but 'moshers' at rock concerts actually behave like molecules in a gas, physicists in the US have discovered.

Researchers at Cornell University in New York analysed YouTube videos of mosh pits, in which heavy metal fans leap about and bash into one another. By tracking the dancers' movements, they found that the moshers' speeds obeyed the same mathematical distribution as the speeds of particles in a gas.

The researchers say that their work could help us to understand how panicked crowds move during riots and natural disasters, enabling authorities to develop better plans for emergency situations.

JAMES LLOYD



The scene outside Focus HQ when this issue went on sale

NEWS IN BRIEF

Regrow your teeth

➤ Lose a tooth and you may soon be able to regrow it. Researchers at King's College London took cells from the human gum and mixed them with mesenchyme cells from mice, which can turn into connective tissue. When the cell combination was transplanted into mice, hybrid human/mouse teeth grew. The next step is to find an easily accessible source of human mesenchyme cells.

Vulcan could be real!

➤ 'Vulcan' could be the new name of one of Pluto's moons after it topped an online poll to re-name the dwarf planet's two smallest satellites, currently called P4 and P5. Nearly 40 per cent of respondents to the SETI Institute poll opted for the name of Spock's home planet in *Star Trek*. SETI has passed on the suggestion to the International Astronomical Union.

It may not look much, but the faint dot (circled) could be Spock's homeworld



Fungi could help asthma

➤ Fungi have been found in the lungs of healthy people and asthmatics – but the make-up of the colonies differs. The discovery, by Cardiff University, may provide a new way to treat the condition. "Individual patients may have their sputum tested for fungi and their treatment adjusted," says Dr Hugo van Woerden, who led the research.

UK Astronomers Ltd

in association with **Sky at Night**
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Image courtesy of Nik Szymański



HOT TOPIC

Of course, everyone on the *Focus* team is a highly skilled musician

Does playing music make you more intelligent?

→ CONVENTIONAL WISDOM holds that playing music makes you more intelligent, a possibility that's encouraged countless parents to ferry children to music lessons after school. But Professor Glenn Schellenberg, a psychologist at the University of Toronto, says that taking children to music lessons purely to improve their exam grades is a waste of time.

Schellenberg studied the link between musical training and intelligence in 130 children aged 10 to 12. He found that

when he took into account the likely effect of each child's personality – such as their conscientiousness – and removed it from the equation, the link between music training and intelligence disappeared.

In other words, conscientious children tend to take music lessons and it's their personality type, not their violin playing, that makes them do well at school. "You can explain most of the data out there by saying that high-functioning kids take music lessons," says Schellenberg.

WHAT DO YOU THINK?

Let us know your opinions at twitter.com/sciencefocus using the hashtag #hottopic, and facebook.com/sciencefocus

Your Tweets and Facebook posts



Glen Freeman: It may not make students more intelligent but may improve self-confidence, self-discipline and help them to use their given intelligence.



Jez Gray: To paraphrase Lyall Watson, if the brain was simple enough for us to understand, we'd be too simple to understand it.



Craig Pedder: Playing instruments requires memory, concentration and multitasking. How could it not improve intelligence?



DOOMWATCH with Bill McGuire

The world's biggest natural disasters in waiting



THE SUNDA MEGATHRUST

WHERE: Padang, Sumatra, Indonesia

WHEN THE SUNDA Megathrust fault ruptured in December 2004, it generated one of the biggest earthquakes ever recorded, which in turn spawned the cataclysmic Indian Ocean tsunami. At megathrust faults, one tectonic plate slides, or is subducted, beneath another. In 2004, subduction forces tore open most of the Sunda Megathrust Fault, while other segments ruptured later to trigger further huge quakes in 2005 and 2007. Together, these seismic events have added enormous stress to an adjacent part of the megathrust that last ruptured in 1797. This segment is now fully 'primed' and can rupture at any moment, generating a massive quake as high as magnitude 8.8 and a 5-6m high tsunami. The waves will reach the Indonesian city of Padang – population close to one million – within 30 minutes. While preparations are being made, the level of destruction will be very high.



TA'AL VOLCANO

WHERE: Luzon, Philippines

TA'AL IS A giant volcano located just 50km south of the Philippine capital, Manila. The active cone – known appropriately as Volcano Island – is situated within a 30km-wide lake-filled crater, and is rumbling again after 35 years of slumber. The close proximity of magma and water make eruptions of Ta'al especially violent; the two combining to send searing blasts of boiling water surging across the lake and into the waterside villages. In 1911, more than 1,300 people were scalded to death in this way, and hundreds more in 1965. Signs of unrest in recent months, including swelling of the ground, swarms of earthquakes and releases of carbon dioxide, have monitoring scientists concerned that another eruption might be on its way. With 5,000 people now living on Volcano Island itself and more than 70,000 having their homes on the lake margins, the potential exists for a major disaster.



ATLANTIC HURRICANES

WHERE: Caribbean, US East and Gulf coasts

EVERY YEAR THE Caribbean islands and the Gulf and East coasts of the US are battered by hurricanes, together resulting in hundreds or thousands of deaths and damage costing billions of US dollars. In 2012, Hurricane Sandy alone claimed close to 300 lives and resulted in economic losses totalling an extraordinary \$75 billion. Prospects for the 2013 Atlantic hurricane season – which runs from June to November – look pretty worrying too. Lauded storm tracker, Tropical Storm Risk, is warning in its extended range forecast that the season will be one-third more active than normal. What this means in real terms is that somewhere between eight and 10 hurricanes are expected, between three and five of which will be intense storms capable of massive destruction if they make landfall in an area of high population density.

BILL MCGUIRE is Professor of Geophysical & Climate Hazards at University College London and the author of *Waking The Giant*

READER SURVEY

FOCUS

WIN
an iPad mini!



Here at *Focus* we pride ourselves on being at the cutting edge of science and technology. But to do that, we need your help. We want to find out more about the gadgets you own and how you live so that we can keep you better informed about topics that will interest you. That's why we've put together this short survey, which will only take you a few minutes to complete. And as a thank you, one lucky reader will win a brand new Apple iPad mini, worth £269. The closing date for postal submissions is midnight on 4 May. (If you'd prefer to fill in this survey online, you'll find it at www.sciencefocus.com) **Graham Southorn, Editor**

A) MEDIA READING AND VIEWING

1. How often do you buy *Focus* magazine?

- Always – I am a subscriber ☐ 1
Always – Every issue, but don't subscribe ☐ 2
Quite often – Once in every two/three issues ☐ 3
Occasionally ☐ 4
This is my first issue ☐ 5

2. Which of these magazines do you read?

	Regularly (1)	Occasionally (2)
GQ	<input type="checkbox"/>	<input type="checkbox"/>
How it Works	<input type="checkbox"/>	<input type="checkbox"/>
Men's Health	<input type="checkbox"/>	<input type="checkbox"/>
New Scientist	<input type="checkbox"/>	<input type="checkbox"/>
Science Illustrated	<input type="checkbox"/>	<input type="checkbox"/>
Scientific American	<input type="checkbox"/>	<input type="checkbox"/>
Stuff	<input type="checkbox"/>	<input type="checkbox"/>
The Economist	<input type="checkbox"/>	<input type="checkbox"/>
The Spectator	<input type="checkbox"/>	<input type="checkbox"/>
The Week	<input type="checkbox"/>	<input type="checkbox"/>
T3	<input type="checkbox"/>	<input type="checkbox"/>
Wired	<input type="checkbox"/>	<input type="checkbox"/>
Wonderpedia	<input type="checkbox"/>	<input type="checkbox"/>
Other (please specify)	<input type="checkbox"/>	<input type="checkbox"/>

3. How often do you visit www.sciencefocus.com?

- Never ☐ 1
Only visited it once ☐ 2
Once every couple of months ☐ 3
Once a month ☐ 4
2-3 times a month ☐ 5
Once a week ☐ 6
A few times a week ☐ 7
Daily ☐ 8
More than once a day ☐ 9

4. Which of these newspapers do you read either in print or in digital format?

	Print (1)	Digital (2)	Both (3)
Financial Times	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
The Guardian/Observer	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
The Times/Sunday Times	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
The Telegraph/Sunday Telegraph	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Daily Mail/Mail on Sunday	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
The i (The Independent i)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
The Independent/Independent on Sunday	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Other	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

B) TRAVEL

5. How many of the following types of break do you take per year?

	Write in
Short breaks (less than 5 days) in the UK	<input type="text"/>
Short breaks (less than 5 days) abroad	<input type="text"/>
Longer holidays (5+ days) in the UK	<input type="text"/>
Longer holidays (5+ days) abroad	<input type="text"/>

6. How much do you typically spend per person on your main holiday?

Under £500	<input type="checkbox"/> 1	£1,501-£2,000	<input type="checkbox"/> 5
£501-£750	<input type="checkbox"/> 2	£2,001-£3,000	<input type="checkbox"/> 6
£751-£1,000	<input type="checkbox"/> 3	£3,001-£5,000	<input type="checkbox"/> 7
£1,001-£1,500	<input type="checkbox"/> 4	Over £5,000	<input type="checkbox"/> 8

7. How many leisure flights do you take per year?

	Write in
Short haul	<input type="text"/>
Long haul	<input type="text"/>

8. Approximately how much do you spend in total on flights for you and your family per year?

Please write in: £

9. How many business flights do you take per year?

	Write in number.
Short haul	<input type="text"/>
Long haul	<input type="text"/>

10. Which airlines do you fly with for either business or pleasure?

	Regularly (1)	Occasionally (2)
Air Canada	<input type="checkbox"/>	<input type="checkbox"/>
Air France	<input type="checkbox"/>	<input type="checkbox"/>
American Airlines	<input type="checkbox"/>	<input type="checkbox"/>
British Airways	<input type="checkbox"/>	<input type="checkbox"/>
Cathay Pacific	<input type="checkbox"/>	<input type="checkbox"/>
Delta	<input type="checkbox"/>	<input type="checkbox"/>
Emirates	<input type="checkbox"/>	<input type="checkbox"/>
KLM Royal Dutch Airlines	<input type="checkbox"/>	<input type="checkbox"/>
Lufthansa	<input type="checkbox"/>	<input type="checkbox"/>
Quantas	<input type="checkbox"/>	<input type="checkbox"/>
Turkish Airlines	<input type="checkbox"/>	<input type="checkbox"/>
Virgin	<input type="checkbox"/>	<input type="checkbox"/>
Other (please specify)	<input type="checkbox"/>	<input type="checkbox"/>

11. How do you normally travel for leisure and business?

	Leisure	Business
First class	<input type="checkbox"/> 1	<input type="checkbox"/> 1
Business/club class	<input type="checkbox"/> 2	<input type="checkbox"/> 2
Premium economy	<input type="checkbox"/> 3	<input type="checkbox"/> 3
Economy/budget	<input type="checkbox"/> 4	<input type="checkbox"/> 4

C) EQUIPMENT OWNERSHIP/USAGE

12a. Which of these items do you own?

12b. Which are you planning to buy in the next 12 months or so?

	Own	Planning to buy
Smartphone (iPhone, Samsung etc)	<input type="checkbox"/> 1	<input type="checkbox"/> 1
Other mobile phone	<input type="checkbox"/> 2	<input type="checkbox"/> 2
Tablet (iPad, Nexus etc)	<input type="checkbox"/> 3	<input type="checkbox"/> 3
E-book reader	<input type="checkbox"/> 4	<input type="checkbox"/> 4
Laptop	<input type="checkbox"/> 5	<input type="checkbox"/> 5
Desktop	<input type="checkbox"/> 6	<input type="checkbox"/> 6
Netbook	<input type="checkbox"/> 7	<input type="checkbox"/> 7
DAB radio	<input type="checkbox"/> 8	<input type="checkbox"/> 8
MP3 docking station	<input type="checkbox"/> 9	<input type="checkbox"/> 9
Wireless music streamer	<input type="checkbox"/> 0	<input type="checkbox"/> 0
Headphones	<input type="checkbox"/> 1	<input type="checkbox"/> 1
Stereo/hi-fi equipment	<input type="checkbox"/> 2	<input type="checkbox"/> 2
DSLR camera	<input type="checkbox"/> 3	<input type="checkbox"/> 3
Digital camcorder	<input type="checkbox"/> 4	<input type="checkbox"/> 4
3D television	<input type="checkbox"/> 5	<input type="checkbox"/> 5
HD television	<input type="checkbox"/> 6	<input type="checkbox"/> 6
Smart TV	<input type="checkbox"/> 7	<input type="checkbox"/> 7
Transparent TV	<input type="checkbox"/> 8	<input type="checkbox"/> 8
LCD projector	<input type="checkbox"/> 9	<input type="checkbox"/> 9
Games console	<input type="checkbox"/> 0	<input type="checkbox"/> 0

13. What are your three favourite brands of IT, audio and electronic equipment?

	Write in
1.	<input type="text"/>
2.	<input type="text"/>
3.	<input type="text"/>

14. How often do you use each of the following for personal purposes? If you don't own/use the device, please leave blank.

	Regularly (1)	Occasionally (2)
Smartphone	<input type="checkbox"/>	<input type="checkbox"/>
Other mobile phone	<input type="checkbox"/>	<input type="checkbox"/>
Tablet (iPad, Nexus etc)	<input type="checkbox"/>	<input type="checkbox"/>
E-book reader	<input type="checkbox"/>	<input type="checkbox"/>

15. And how often do you use each of the following for business purposes? If you don't own/use the device, please leave blank.

	Regularly (1)	Occasionally (2)
Smartphone	<input type="checkbox"/>	<input type="checkbox"/>
Other mobile phone	<input type="checkbox"/>	<input type="checkbox"/>
Tablet (iPad, Nexus etc)	<input type="checkbox"/>	<input type="checkbox"/>
E-book reader	<input type="checkbox"/>	<input type="checkbox"/>

16. If you own a smartphone what operating system do you have?

- Android ☐ 1
Blackberry ☐ 2
Apple iOS ☐ 3
Symbian ☐ 4
Windows Phone ☐ 5
Not sure ☐ 6
Other (please specify) ☐ 7

17. What make is the tablet computer you use?

- Apple iPad 1 ☐ 1
Apple iPad 2 ☐ 2
Apple iPad 3 ☐ 3
Apple iPad mini ☐ 4
Samsung Galaxy ☐ 5
Blackberry PlayBook ☐ 6
Amazon Kindle Fire ☐ 7
Microsoft Surface ☐ 8
Google Nexus ☐ 9
Other (please specify) ☐ 0

18. How much are you planning to spend in the next 12 months on each of these types of equipment?

	Over £5k	£3k-£5k	£1k-£3k	Under £1k	Nothing
Laptop/desktop/netbook	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
Printers/scanners	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
Audio and visual equipment	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
Games/consoles	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
Photography equipment	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
DVDs	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
Fashion & grooming	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
Household/garden gadgets	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5

D) CARS

19. How many cars are there in the household?

	Write in
	<input type="text"/>

20. What type(s) of car do you own?

Family car	<input type="checkbox"/> 1	Sports car	<input type="checkbox"/> 4
Eco-friendly car	<input type="checkbox"/> 2	4x4	<input type="checkbox"/> 5
City car/runaround	<input type="checkbox"/> 3	Executive car	<input type="checkbox"/> 6

READER SURVEY

21. Which make(s) of car do you own?

Audi	<input type="checkbox"/> 1	Mercedes-Benz	<input type="checkbox"/> 1
BMW	<input type="checkbox"/> 2	Nissan	<input type="checkbox"/> 2
Citroën	<input type="checkbox"/> 3	Peugeot	<input type="checkbox"/> 3
Fiat	<input type="checkbox"/> 4	Renault	<input type="checkbox"/> 4
Ford	<input type="checkbox"/> 5	Saab	<input type="checkbox"/> 5
Honda	<input type="checkbox"/> 6	Toyota	<input type="checkbox"/> 6
Jaguar	<input type="checkbox"/> 7	Vauxhall	<input type="checkbox"/> 7
Land Rover	<input type="checkbox"/> 8	VW	<input type="checkbox"/> 8
Mazda	<input type="checkbox"/> 9	Volvo	<input type="checkbox"/> 9
Other	<input type="checkbox"/> 0		

(please specify)

22. Approximately what did you pay for your main car?

Write in

£

23. How often do you change your main car?

Yearly	<input type="checkbox"/> 1
Every 2 years	<input type="checkbox"/> 2
Every 3 years	<input type="checkbox"/> 3
Every 4-5 years	<input type="checkbox"/> 4
Less often	<input type="checkbox"/> 5
Not sure, it depends on my circumstances	<input type="checkbox"/> 6

24. And is your main car usually:

Bought new	<input type="checkbox"/> 1
Bought secondhand	<input type="checkbox"/> 2

25. When are you planning to buy your next car?

Within a year	<input type="checkbox"/> 1
In 1-2 years	<input type="checkbox"/> 2
In 2-3 years	<input type="checkbox"/> 3
Longer	<input type="checkbox"/> 4
Don't know	<input type="checkbox"/> 5

26. And approximately how much are you planning to spend on this car?

Write in

£

E) YOU AND YOUR WORK

27. What is your current working status?

Employed full-time	<input type="checkbox"/> 1
Employed part-time	<input type="checkbox"/> 2
Studying full-time	<input type="checkbox"/> 3
Studying part-time	<input type="checkbox"/> 4
Retired	<input type="checkbox"/> 5
Not working	<input type="checkbox"/> 6

If you are not employed full-time or part-time please omit this section and go to Section G

28. If you are in employment, what type of industry/profession do you work in?

Medicine	<input type="checkbox"/> 1
Law	<input type="checkbox"/> 2
Education – Primary	<input type="checkbox"/> 3
Education – Secondary	<input type="checkbox"/> 4
Education – Further/higher	<input type="checkbox"/> 5
Financial	<input type="checkbox"/> 6
Research	<input type="checkbox"/> 7
Science/Tech	<input type="checkbox"/> 8
IT	<input type="checkbox"/> 9
Engineering	<input type="checkbox"/> 0
Retail	<input type="checkbox"/> 1
Local government	<input type="checkbox"/> 2
Civil service	<input type="checkbox"/> 3
Other (please specify)	<input type="checkbox"/> 4

29. Approximately how many employees work in your organisation?

Write in

30. What is your position in this organisation?

Company owner/partner	<input type="checkbox"/> 1
Chairman	<input type="checkbox"/> 2
Managing Director	<input type="checkbox"/> 3
Senior Manager/Head of Department	<input type="checkbox"/> 4
Middle Manager	<input type="checkbox"/> 5
Professional (lawyer, accountant, etc)	<input type="checkbox"/> 6
Executive/Junior Management	<input type="checkbox"/> 7
Administration	<input type="checkbox"/> 8
Other	<input type="checkbox"/> 9

31. Do you manage any other employees?

Yes	<input type="checkbox"/> 1
No	<input type="checkbox"/> 2

32. If yes, approximately how many?

Write in

F) SPENDING WITHIN ORGANISATION/WORK-PLACE

33. Do you have influence on how your organisation spends its budgets on IT i.e. computers, servers, internet etc?

Yes, regularly	<input type="checkbox"/> 1
Yes, occasionally	<input type="checkbox"/> 2
Never (Skip to Q36)	<input type="checkbox"/> 3

34. Approximately how much did your organisation spend on IT equipment in the last 12 months?

Write in

£

35. And approximately how much do they plan to spend on IT equipment in the next 12 months?

Write in

£

36. Do you have influence on how your organisation spends its budgets on staff recruitment?

Yes, regularly	<input type="checkbox"/> 1
Yes, occasionally	<input type="checkbox"/> 2
Never (Skip to Q38)	<input type="checkbox"/> 3

37. Which of these positions do you recruit?

(Tick as many as apply)

Administration	<input type="checkbox"/> 1
Executive/Junior management	<input type="checkbox"/> 2
Middle management	<input type="checkbox"/> 3
Senior manager/board	<input type="checkbox"/> 4
Managing Director and above	<input type="checkbox"/> 5

38. Do you have influence on how your organisation spends its marketing budget?

Yes, regularly	<input type="checkbox"/> 1
Yes, occasionally	<input type="checkbox"/> 2
Never (Skip to Q41)	<input type="checkbox"/> 3

39. Approximately how much did your organisation spend on internet advertising/online search optimisation etc in the last 12 months?

Write in

£

40. Approximately how much did your organisation spend on other advertising (i.e. print/poster/TV) in the last 12 months?

Write in

£

41. Do you have influence on how your organisation spends its budgets on environmental matters?

Yes, regularly	<input type="checkbox"/> 1
Yes, occasionally	<input type="checkbox"/> 2
Never (Skip to Q43)	<input type="checkbox"/> 3

42. Approximately how much did your organisation spend on environmental matters in the last 12 months?

Write in

£

43. Do you have a company car?

Yes	<input type="checkbox"/> 1
No	<input type="checkbox"/> 2

44. Did you have any choice in the make?

Yes, free choice	<input type="checkbox"/> 1
Yes, some choice	<input type="checkbox"/> 2
No	<input type="checkbox"/> 3

45. Do you have influence on the company cars leased/bought by the organisation you work for?

Yes, regularly	<input type="checkbox"/> 1
Yes, occasionally	<input type="checkbox"/> 2
Never (Skip to Section G)	<input type="checkbox"/> 3

46. How many cars does the organisation source for its employees?

Write in

G) ABOUT YOU

47. Are you:

Male	<input type="checkbox"/> 1
Female	<input type="checkbox"/> 2

48. Are you:

Married/living with partner	<input type="checkbox"/> 1
Single	<input type="checkbox"/> 2
Divorced/separated	<input type="checkbox"/> 3
Widowed	<input type="checkbox"/> 4

49. Which age group are you in?

Under 18	<input type="checkbox"/> 1	46-55	<input type="checkbox"/> 5
18-25	<input type="checkbox"/> 2	56-65	<input type="checkbox"/> 6
26-35	<input type="checkbox"/> 3	66-75	<input type="checkbox"/> 7
36-45	<input type="checkbox"/> 4	Over 75	<input type="checkbox"/> 8

50a. What is your highest educational level?

50b. What is your highest educational level in science?

	Overall	Science
O level/GCSE	<input type="checkbox"/> 1	<input type="checkbox"/> 1
A level or similar	<input type="checkbox"/> 2	<input type="checkbox"/> 2
BTEC	<input type="checkbox"/> 3	<input type="checkbox"/> 3
HNC/HND	<input type="checkbox"/> 4	<input type="checkbox"/> 4
Degree	<input type="checkbox"/> 5	<input type="checkbox"/> 5
Higher degree	<input type="checkbox"/> 6	<input type="checkbox"/> 6

51. What is your total/combined household income?

Under £20,000	<input type="checkbox"/> 1	£50-£69,999	<input type="checkbox"/> 5
£20-£29,999	<input type="checkbox"/> 2	£70-£99,999	<input type="checkbox"/> 6
£30-£39,999	<input type="checkbox"/> 3	£100-£149,999	<input type="checkbox"/> 7
£40-£49,999	<input type="checkbox"/> 4	£150,000+	<input type="checkbox"/> 8

52. Is your home:

Mortgaged	<input type="checkbox"/> 1	Rented	<input type="checkbox"/> 3
Owned outright	<input type="checkbox"/> 2	Other	<input type="checkbox"/> 4

53. Would you be willing to take part in future research for Focus?

Yes	<input type="checkbox"/> 1
No	<input type="checkbox"/> 2

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INSIDE SCIENCE

ROBERT MATTHEWS

WHILE LISTENING TO the radio news over breakfast recently, I heard one of those stories that made me splutter with incredulity over my scrambled eggs. According to the report, vandalism is on the decline, with official statistics showing that levels of mindless damage to property in England have plunged by over a third since 2007.

My initial reaction to these stats was to dismiss them. Clearly, whoever compiled them had slept through those summer riots a year or so ago, and had certainly never been round my neighbourhood. It struck me that maybe vandalism is now so bad that people can no longer be bothered to report it. Yet the decline had apparently been seen not only in reported crime figures, but also in surveys where people are picked at random to report their experiences of crime.

I had barely grappled with the idea that the stats were true, when the story became even more annoying, with pundits popping up to offer their own pet explanation for the decline. Some pointed to the wider use of CCTV and vandal-resistant materials, while others claimed the cause was reduced boredom – because every would-be vandal now has a smartphone to distract them.

Some explanations seemed a bit more plausible than others. For instance, it turns out that boozing – a prime cause of vandalism – has also been on the decline among young people since the late 1990s (who knew?). Another suggested reason for the decline in window smashing is the phasing out of lead in petrol. Certainly, as with booze, studies have shown a correlation between low IQ, violent behaviour and exposure to lead. But this is where the search for explanations starts to go awry.

For starters, correlation isn't the same as causation. There's doubtless a correlation between booze and unwanted pregnancy, but that doesn't mean beer makes you pregnant (at least, I hope not).

All this highlights the fact that it's extremely hard to demonstrate cause and effect. Indeed, it's one of the great unsolved problems in science. We're not talking about simple science here – like lab experiments where things can be kept neat and tidy. We're talking about messy science, like trying to discover why kids no longer trash vending machines.



“We’re talking about messy science, like trying to discover why kids no longer trash vending machines”

A host of tricky questions suddenly rear their heads. The statistics talk blithely of ‘acts of vandalism’, but they take many forms, and may well have different motivations. Did kids vandalise a vending machine because they were bored or because they wanted to steal its contents? The statistics can't tell us the motivation, yet without that we can never be certain of what caused the decline.

One hallmark of a genuine cause is that whenever it's present the associated effect appears, and whenever it's absent the effect vanishes too. Simple – until you apply it to, say, lead-free petrol as a cause of vandalism. Kids trashed stuff well before the invention of petrol-driven cars, and they still do today, even though petrol is lead-free. So whatever else it is, lead can't be the sole cause. At best, it may be a contributor. That's because the supposed link between lead and bad behaviour may also be flawed. Studies have shown that high lead levels can be nothing more than a consequence of being raised on nasty estates near busy roads, and thus appear to be linked with violent behaviour while the true causes lie elsewhere.

Some very clever people have been trying for years to find ways of cutting through all this complexity to reveal the causes of complex phenomena. I wish them luck, but I don't think they'll succeed. Some

things in life are just too damned complex. And we should be deeply sceptical of experts touting single, all-encompassing causes. ■

ROBERT MATTHEWS is Visiting Reader in Science at Aston University, Birmingham

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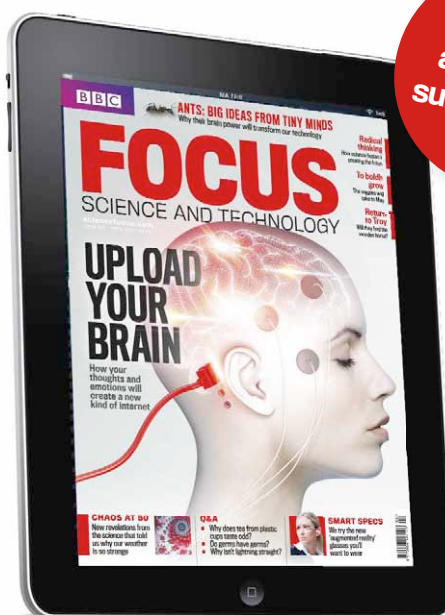
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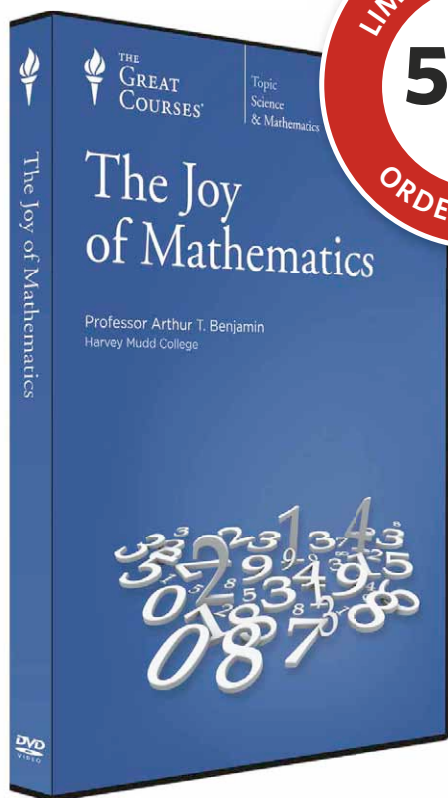
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HIDDEN TREASURES

HELEN CZERSKI

WE LIVE IN a world obsessed by perfection. Everything is supposed to be better if it's shiny, defect-free and stronger than a Sherman tank. But be careful what you wish for, because a flawless world wouldn't work nearly as well.

Imperfections are tools, and we would be lost without them. Of course, flaws are not always convenient. I spent part of last summer next to a fortress-sized lump of ice in the Arctic for the BBC Two programme *Operation Iceberg*. One day, a long, deep boom smashed through the normal peace and quiet. From the top of the ship, the cause was obvious – a massive fracture had just opened up, and a whole section of the iceberg had split off. I'm used to thinking about fractures as tiny things, but this one was incredible – a single crack which was at least 3km in length. And it will have started at one tiny flaw in the ice.

Imagine bending a long thin object: a chocolate bar, for example. If the chocolate has flat surfaces, each side is stretched evenly. It's hard to break. But if you put a notch in it, the section of chocolate just underneath also has to do the job of the bit you've taken out. The chocolate will break at the notch. It's not because it's thinner at that point, but because the sharp point of the notch concentrates the force in a very small area.

In a flawless object, the stress you put on the material by pushing, stretching, bending and twisting is relatively evenly spread. Features like notches, tiny voids and cracks make the pattern of stress more complicated, concentrating the stress in some bits and relieving it in others. If you could see stress as colour, every object you pushed on would suddenly light up with bands of colour, and the flaws would be tiny pinpoints of dazzlingly bright light. Those pinpoints are vulnerable: overloaded already, they can't take much more.

The iceberg was being bent by the ocean, and it was full of flaws. One of

those tiny places will have given way first, and once the fracture started, there was no stopping it. Billions of tonnes of ice broke free, and our ship and its occupants had to scramble to get out of danger. But the effect of

“Billions of tonnes of ice broke free, and our ship had to scramble to get out of danger. But the effect of a flaw doesn't have to be catastrophic. Flaws give us control”

a flaw doesn't have to be catastrophic. Flaws give us control. If you put a notch in a material, you know exactly where it's going to break. Chocolate is the obvious example, but there's also the perforations in kitchen towel, the zigzags at the top of crisp packets and the fold you put in a piece of paper before you tear it.

A tiny flaw can have all sorts of consequences, from icebergs splitting to enjoying a bar of chocolate



Having a line of holes or a notch also means that you don't have to pull the object as hard to get it to break. All those little defects are concentrating the force you use, amplifying what you have to offer. We don't even have to put them there ourselves. Think about peeling a banana. Those ridges down the sides are weaker than most of the skin, so they give way first. Breaking into a banana is something that you can do in a satisfyingly beautiful way. Not so with an orange. They don't have any external weaknesses, so you have to do a lot of work to earn your pile of messy tiny pieces of orange peel and fingernails full of zest. But once inside, aren't

segments convenient?

Perfection is fairly boring anyway: just like people, it's the flaws that make most things interesting. ■

DR HELEN CZERSKI is a physicist, oceanographer and BBC science presenter whose shows include *Operation Iceberg* and *Orbit*



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By Matt Kaplan, author of *The Science Of Monsters: Why Monsters Came To Be And What Made Them So Terrifying*

THE SCIENCE OF ZOMBIES

PLUS 4 MORE MONSTERS EXPLAINED

You may be terrified to discover that the beasts of piercing stare and hooked claw that walk your nightmares are based on science fact

THE HALF-MAN, half-beast minotaur, the fire-breathing dragon, the werewolf and its corrupting bite... all the stuff of utter fiction. Surely the monsters of campfire stories and Hollywood horror can have no basis in reality? That would be ridiculous. This is what we have deluded ourselves into believing but it is, astonishingly, wrong.

While there never was a real werewolf that could curse others by biting deeply into their flesh, this is not how our ancestors saw things. Once upon a time, diseased wolves ran rampant across the European landscape. Countless souls were mauled and the pain of such attacks was far greater than the mere tearing of flesh. Just a single bite

from these beasts would spread their infection and, within months, a contaminated person would be stripped of their humanity, snarl, hiss and ultimately be driven to bite others around them. Today, our understanding of epidemiology allows us to see this hideous transformation as the result of the rabies virus. But long ago it was the curse of the werewolf.

Make no mistake, monsters are fictional creatures, but they did not emerge from nothingness. Our very worst nightmares have their origins firmly rooted in reality, taking form from terrifying phenomena that our ancestors were seeing but could not understand. So here, armed with today's scientific knowledge, we'll shed light on the birth of these horrific beasts. ➔



Even the creatures of
your nightmares have a
logical explanation... well,
we hope so anyway

ZOMBIES

On a Caribbean island, zombies walk the streets

THE ISLAND OF Haiti is rich with legends of the dead being brought back from the grave, but these were thought to be nothing more than myths until a remarkable story started to unfold. In May 1962, a man turned up at an American-run hospital in Haiti sick with fever, spitting up blood and suffering terrible body aches. His condition deteriorated and he was declared dead several hours later. The doctors noted that he had very low blood pressure, hypothermia, respiratory failure and numerous digestive problems. His sister identified the body and made arrangements for his burial.

In 1981, the sister was approached by a man at her village market who introduced himself using the boyhood name of her dead brother. She was stunned. This was a name that only she and a few family members knew. The man said that he'd been made into a zombie and forced to work on a plantation until his zombie master died. The media went crazy over the story and Dr Lamarck Douyon, director of the Psychiatric Institute in Port-au-Prince, made up his mind to test whether this zombie tale could possibly be true.

Extensive psychiatric tests proved that the man really was the brother. This led Douyon to conclude that there had to be something real about zombie mythology – something

must have made the man appear dead when he actually was not. So he contacted the-then Harvard ethnobotanist Edmund Wade Davis – currently the explorer in residence at National Geographic – to investigate what it was that these zombie masters were actually doing.

DEADLY CONCOCTIONS

Having carried out numerous interviews with the masters, Davis discovered that they were developing complex poisons from local ingredients (see 'Zombie chemistry', opposite), which the victim inhaled or absorbed through their skin. This brought them to the brink of death; actually feeding the poisons to victims would have meant they were dead rather than just looking it, so they would have been of no use to their masters.

These poor souls were then buried alive and later dug up. The zombie masters told Davis that they then had to beat the zombie to drive off its old spirit, tie it to a crucifix, feed it a paste made from hallucinogenic cucumbers and then baptise it with a zombie name. Davis realised that after this ordeal, victims were so mentally damaged that they would do whatever they were told. And while they were not the undead, they might as well have been.

WHEN PATIENTS RISE FROM THE DEAD

Funeral home workers in the Colombian city of Cali got the shock of their lives when an apparently dead 45-year-old woman being prepared for burial started breathing again. Noelia Serna had been admitted to hospital after suffering a heart attack and was declared dead. After coming back to life in the funeral home, she was duly transferred back to hospital.

This apparent miracle, back in 2010, is an example of the Lazarus syndrome, where a patient's circulation returns some time after attempts at resuscitation have failed. But

far from being animated corpses like the zombies we often imagine, these patients are very much alive.

At least 25 incidences have been reported since 1982, and why it happens is far from clear. One suggested mechanism is a delay in adrenaline administered by medical staff reaching the heart.

In a report on one incidence of the Lazarus effect in the journal *Anesthesia & Analgesia*, doctors in Pittsburgh say it makes the timing of organ harvesting for transplants more 'problematic'.



If anyone offers you
a hallucinogenic
cucumber, say no,
unless you want
to end up like this



ZOMBIE CHEMISTRY*

The poison that creates the undead

INGREDIENTS

Toxins from the toad known as *Bufo marinus*. It is known for being something of a chemical nightmare, producing both numbing agents and hallucinogens.

Puffer fish have toxins that cause paralysis, depress respiration, reduce circulatory activity, and cause patients to believe they are floating over their own bodies. The fish are a critical component of a zombie potion.

Some species of plant used, such as *Albizia lebbbeck* are unstudied and their chemical effects are unknown.

Others are better understood – *Mucuna pruriens*, for example, has hallucinogenic effects.

MIXING

The animal components are heated together with human remains before being placed in a mortar with the plant components and pounded to a granular consistency. The concoction is then sifted to produce the final product.

APPLICATION

Give someone the poison to drink and it "kills them too completely," a witch doctor told Harvard ethnobotanist Edmund Wade Davis. Instead, the poison is applied repeatedly to the victim's skin, an open wound, or it is blown across the victim so they inhale it. Some witch doctors add broken glass to the brew, so if it is placed on a doorknob the skin will be broken and the poison is more likely to take effect.



*A warning to all would-be witch doctors – creating a zombie-inducing cocktail is dangerous and illegal. We have not listed all of the ingredients here.

MINOTAUR

A half-man, half-bull that tore its quarry to pieces

AT FIRST GLANCE, the minotaur seems absurd. A half-man, half-bull creature? The idea is as ridiculous as it is biologically impossible. However, writings from the 3rd Century BC hint that the fears behind the myth were real enough. While most descriptions of the minotaur's physical form are vague, its bellows were described as so terrible that they could be heard for miles emanating from the labyrinth on the Greek island of Crete where it was imprisoned. Bellows coming from an underground maze... might the rise of the minotaur be linked to earthquakes?

SUBTERRANEAN ROAR

Crete is tectonically active, but so are many locations around the globe that do not have minotaur myths associated with them. Yet a 2007 study by an international team of researchers published in *Nature Geoscience* hints that Crete has had earthquakes of truly epic proportions. The study analysed the carbon isotopes of fossilised marine organisms along the island's coast to work out when they died and through this analysis the team discovered something staggering. Countless animals died at precisely the same moment in 365AD.

As the team looked closer, it became clear that the animals perished because they dried out when Crete was pushed nearly 10m out of the ocean in a single moment. Ten metres of uplift from a single earthquake... that really is the stuff of nightmares. But 365AD is long after the days when the minotaur came to be. Crucially though, this tectonic incident wasn't just an isolated event.

A 2008 paper published in *Earth And Planetary Science Letters* by an international team of scientists identified boulders along the Greek coast with shelled marine animals attached to them. The boulders had been thrown out of the sea by earthquake-induced tsunamis, and the animals attached to them quickly desiccated. Carbon analysis of these animals allowed the team to date the moments when the tsunamis took place. As expected, some boulders dated to 365AD, but many had been thrown from the sea thousands of years earlier when the minotaur was only just emerging as a monster.

Could subterranean bellows be the result of geothermal activity or a demented man-bull? If you're reading *Focus* you know the answer

DID YOU KNOW?

The god Poseidon was responsible for creating the bull that inseminated the queen of Crete, leading to the birth of the minotaur. Known as the god of the ocean, Poseidon was also the god of earthquakes. Mere coincidence? Doubtful.

The Leviathan would eat Jaws as an appetiser

LEVIATHAN

Familiar sea creatures or Biblical beast?

IT WAS A horrid sea monster of incomprehensible size with 'rows of shields tightly sealed together' on its back and smoke that poured from its nostrils. This beast in the pages of the *Bible* sounds terrible. But the elements of the natural world that led to the imagining of the Leviathan of the Mediterranean are easy to identify.

While the image of an animal with shields for skin is vivid, it is hard for a biologically-trained mind not to wander to thoughts of reptiles, or more specifically, to think of the large and hard scales of crocodiles living in the Nile. Smoke pouring out of nostrils had to have emerged from people seeing whales blasting air out of their blow holes and this goes along with the description of the beast rising up out of the water and thrashing about – it's typical whale-breaching behaviour.

DID YOU KNOW?

Some of the earliest dragons of mythology were constrictors from Assyrian legend. A 2011 study may show why, revealing that over the last 100 years pythons have eaten more than nine per cent of people born to each generation in hunter-gatherer tribes in the Philippines.

DRAGONS

A fire-breathing beast that rises from the ground

DRAGONS OF MEDIEVAL legend are not described much physically. It was their fiery breath that drew attention. The tales of the historian Geoffrey of Monmouth, who lived in the 12th Century, hint that there might be some truth behind this.

In Monmouth's writings, ancient British king Vortigern was forced to flee to Welsh hills as the Saxons invaded. Near Snowdonia, he demanded that a fort be built. Yet every time his men began constructing the walls they fell over. Vortigern sought advice from his wise men who told him he needed to spill the blood of a child not born from the union between man and woman.

Vortigern sent them off to find such a child and, when they came to Carmarthen, they discovered two boys arguing. One of the children insulted the other as a bastard with no father. Bingo! The wise men grabbed the kid and ran for it. Upon meeting Vortigern, the boy told him it was the dragons below the ground that were responsible for the tumbling

walls. Vortigern ordered his men to dig into the ground and, sure enough, they found dragons 'panting' flame.

People assume Monmouth made this up, but there is science here. Wales has many regions where coal gas collects in underground pockets. People who went digging into them with tools that sparked against the rocks would have caused explosions. We understand this as mere combustion today, but back then, the blasts of foul smelling fire belonged to the deadly breath of a monster.

DID YOU KNOW?

Contrary to what a lot of people believe, there really are whales in the Mediterranean. And some of the whales living there are really big animals, including fin whales and the carnivorous sperm whales responsible for the tales surrounding *Moby-Dick*.

THE FUTURE OF MONSTERS

What new horrors will our imaginations create?

GIVEN THE TRENDS of the past 100 years, people in the future will likely be scared witless by a monster spawned from science. Books like *Frankenstein* and *The Island Of Dr Moreau* were only the beginning, with people fearing what transplants and blood transfusions were capable of bringing into our world. Now films like *Jurassic Park*, *Species*, and *Splice* scare us with genetically manipulated horrors and it appears to be a recurring nightmare.

GENETIC HORROR

A team of scientists at the University of Tokyo is already raising mice that have been genetically altered to carry the pancreas of rats. This might not sound like much of a feat, but mice and rats are more distantly related than humans and chimpanzees.

So how would people view a human grown with several organs belonging to a chimpanzee or some other mix of animals? Or worse, how might a chimpanzee grown with a human brain be viewed? Certainly, such a creature would have to be given the same civil rights as a human being, but what would a mind placed in such an environment endure?

Thankfully, this is still just the stuff of science fiction but, in the next 100 years, it might not be. As these areas of science march ever closer to reality it is only natural for our fears of how such experiments might go very wrong to make their way into literature and film with ever-increasing frequency.

Indeed, this is why monsters are so valuable. They provide a face for our fears, allowing us to see them more clearly, and perhaps most importantly, understand what it is about the world that truly terrifies us. ■

You'd be annoyed too if you woke up to find that they'd transplanted your brain into the body of a gorilla

ILLUSTRATOR: NATHAN MCKENNA



The Science Of Monsters
By Matt Kaplan
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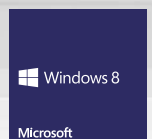
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TWO

Seventy-five years ago a scientist discovered a new wonder material: Teflon. On the anniversary of this chance find, **Jon Agar** reveals a few more of science's fortunate discoveries



TEFLON

IT'S A POPULAR misconception that the non-stick coating was a by-product of NASA's endeavours in space. In truth, Teflon was first created by a scientist named Roy Plunkett [pictured] who was toying with CFC gases to create a new refrigerant. Plunkett stored cylinders of a gas known as tetrafluoroethylene (TFE) in dry ice so they wouldn't explode in the lab, but when he came to use the gas, he discovered waxy, white flakes in its place. This new substance was incredibly slippery and stable, resistant to heat, water, acid and pretty much everything else he could throw at it. It wasn't until French engineer Marc Gregoire worked out how to bond it to aluminium that the first non-stick pan was produced and the brand Teflon soon followed.



VIAGRA

AT FIRST, SILDENAFIL seemed to be a promising new drug for heart disease, including angina. But when it was trialled at a Swansea hospital, male test patients reported an odd side effect: unexpected erections. Marketed as Viagra in the late 1990s, the drug became a massive hit for Pfizer. This pattern of invention is surprisingly common: users, as well as producers, can make discoveries.



MICROWAVE OVEN

DURING WORLD WAR II, Percy Spencer was a senior engineer for Raytheon, a defence contractor supplying radar equipment to the US military. In 1946, he was working at MIT's Radiation Laboratory to develop a more powerful magnetron – the vacuum tube at the heart of radar devices – when, standing in front of one of his test models, he noticed that a chocolate bar in his pocket had melted. Intrigued, he tried holding a bag of unpopped popcorn up to the device – and so the microwave oven was born, with Raytheon's industrial-sized 'Radarange' [pictured] going on sale the following year. It's now the saviour of many a tired 9-5 worker looking for a quick evening meal.



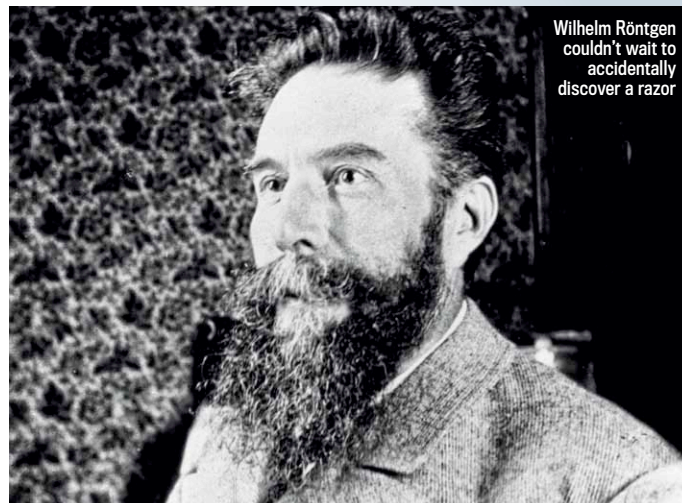
SYNTHETIC DYE

AT THE AGE of 18, William Perkin was working as a lab assistant in London. He'd been tasked with coming up with a new way of producing quinine, an expensive antimalarial drug. In 1864, after a failed attempt, he noticed a potent purple sludge at the bottom of one of his beakers. Rather than throwing it away, Perkin tested it, soon realising he'd created an artificial dye that was more vibrant than anything from nature. This sparked a whole new industry looking to capitalise on what chemists could create.



RADIO ASTRONOMY

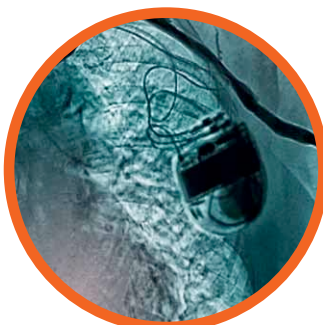
BOTH THE ORIGINS of, and greatest discovery by, radio astronomy were accidental. Karl Jansky [pictured] was an engineer investigating interference in telephone lines. The errant signals were found to come from celestial objects, and radio astronomy was born. Three decades later, radio engineers Arno Penzias and Robert Wilson were also investigating a stubborn hiss. What they'd found was the last fading echo of the Big Bang, now known as Cosmic Microwave Background radiation.



Wilhelm Röntgen couldn't wait to accidentally discover a razor

X-RAYS

IN 1895, PHYSICIST Wilhelm Röntgen was busy in his University of Würzburg lab investigating the properties of cathode rays. Suddenly he noticed a flicker on a barium platinocyanide screen. Surprise turned to shock when he saw a skeletal hand. Some mysterious emanation was passing through the air – and through his flesh, allowing his bones to cast shadows on the dimly glimmering screen. X-rays – the 'X' stood for their unknown nature – were soon replicated in laboratories around the world. Within two decades, X-rays found extraordinary medical applications.



PACEMAKER

WE'VE ALL DONE it: reached into the toolbox and pulled out the wrong instrument. In Wilson Greatbatch's case this simple mistake resulted in the invention of the first practical implantable pacemaker. Greatbatch was actually trying to make a circuit that could record fast heartbeats, but when he inadvertently pulled out a 1-megaohm resistor instead of the 10,000-megaohm resistor he'd intended to use, the finished product pulsed for 1.8 milliseconds, stopped for one second and then repeated. It was the unmistakable rhythm of a heartbeat at rest. The first successful pacemaker was implanted in a 77-year-old in 1960, who lived for 18 months after the device was inserted.



TEXT MESSAGING

IN 1987, EUROPEAN bureaucrats set about drawing up a new technical standard for mobile phones. Fully digital cellular phones – smaller and more portable than their predecessors – were being designed, and the officials wanted a system that would work across the whole of Europe, all in the spirit of European co-operation and harmony. Written into the script was a tiny detail that enabled telecoms engineers testing the system to send short messages back and forth between themselves, to help manage the mobile network. But consumers soon discovered this 'Short Message Service' (SMS), and, to the immense surprise of the phone operators, loved it. We've been texting ever since.



SACCHARIN

SURELY ONE OF the most important rules in chemistry is to *always* wash your hands. Luckily for the sweet-toothed among us, Constantin Fahlberg didn't adhere to strict hygiene codes back in 1878. After trying to create new derivatives of coal tar in his laboratory at Johns Hopkins University in Baltimore, USA, he went home to eat his dinner, which he found to be unusually sweet. In an interview with *American Analyst*, a leading scientific journal of the time, Fahlberg told a reporter that he immediately ran back to his lab and tasted the contents of every evaporating dish and beaker till he found the sweetener now known as saccharin. Fortunately for him, none of the other liquids turned out to be poisonous.



SUPER GLUE

DURING WORLD WAR II, Harry Coover [pictured], a chemist at Eastman Kodak, was head of a team that was trying to concoct a clear plastic that could be used to create transparent gun sights. One unsuccessful attempt created a gloop that simply stuck to everything it touched – an experience that'll be familiar to anyone who's ever spilt superglue on their hands. They had created what's known as a cyanoacrylate. Coover soon discovered that cyanoacrylates had the unusual property of rapidly polymerising – joining together in a sticky mess – when in the presence of moisture. Here, he realised, was a glue that was immensely strong but required neither heat nor pressure to activate.

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MASTERS OF MIND CONTROL

New technology has the power to put our actions and even our personalities in someone else's hands, says **Kathleen Taylor**



ON 28 NOVEMBER 1953, a US biochemist called Frank Olson fell to his death from the window of a New York hotel. The verdict was suicide. Twenty years later, the secretive CIA project called MKULTRA was officially halted. During US government investigations, the CIA admitted having given Olson the mind-altering drug LSD shortly before he died. His family, who received a settlement in 1976, allege to this day that he was murdered to

The CIA's experiments 50 years ago failed, but could mind control now be a viable proposition?

ILLUSTRATOR: CONEYL JAY

→ prevent him going public with details of his research in biological warfare and the military use of LSD.

Olson was not MKULTRA's only guinea pig. Yet because most of the project's documents were destroyed, we may never know how many people – including the mentally ill and terminal cancer patients – were experimented on without their knowledge and consent. The project was set up to pursue an ancient fantasy: controlling people's minds. Now, 40 years after it was stopped, research into mind control is more advanced than ever.

Progress in computing power, genetics and neuroimaging have created new technologies for manipulating brains with unprecedented precision. And these days the aim is not to control the minds of captive soldiers or manipulate the thinking of Soviet bloc leaders. These days, mind control is aimed a little closer to home.

Techniques for controlling the human brain could treat mental afflictions ranging from addiction to obsessive-compulsive disorder and depression. And while the military aims haven't disappeared, today the dream is of developing super soldiers who are not crippled by fear in life and death situations, can make brilliant tactical decisions when running on two hours' sleep a night and could even know the directions to the next rendezvous point in deepest Afghanistan without a map – the route being fed directly to their brains.

As well as the targets, the techniques of mind control have changed – as have the ethics. Out go the secrets and covert experimentation: much of today's research is announced via press release, or reported on blogs and official websites.

ILLUMINATING THE BRAIN

Among the most promising of new mind control techniques is optogenetics. Brain cells, or neurones, are made to respond to light by the insertion of light-sensitive

genes derived from microbes. Pulses of light – perhaps delivered through a fibre-optic wire – can then be used to control neural circuits, without any of the tissue damage caused by implanted electrodes or the negative side effects of drugs.

The beginnings of research into

240 million dollars was the budget the Pentagon's research arm, DARPA, devoted to cognitive neuroscience in 2011



Neuroscientist Dr Karl Deisseroth in his lab at Stanford University, where he's researching optogenetics

"Advances in computing, genetics and neuroimaging have created new technologies for manipulating brains"

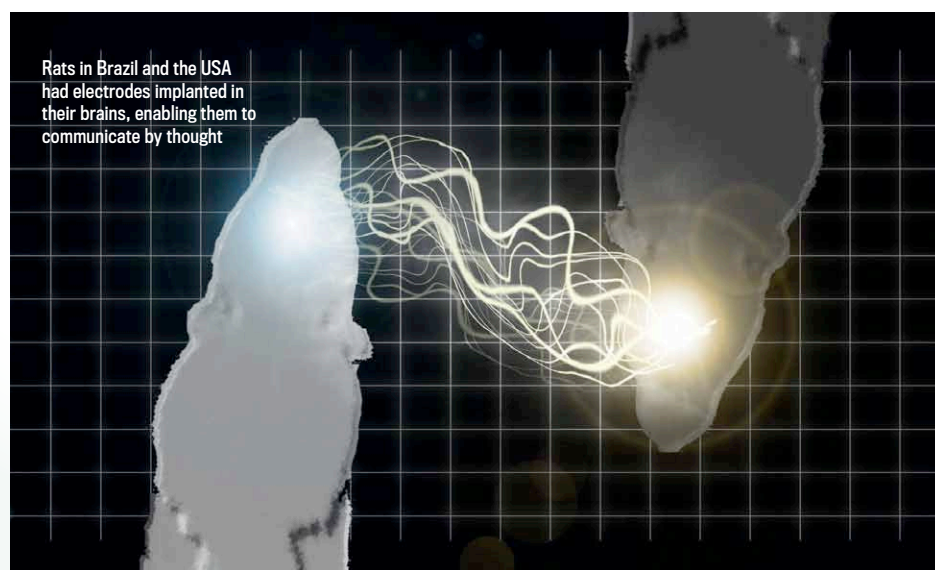
optogenetics have been fairly humble, with research subjects being the likes of microscopic worms, fruit flies and mice. But last year, a team of biologists took a step closer to humans, using optogenetics to change monkeys' eye movements.

"There are already some groups working on optogenetic applications in humans," says Dr Wim Vanduffel, of the University of Leuven and Harvard Medical School, who led the research on monkeys.

Other research on animals gives a small insight into the potential of optogenetics. Neuroscientists led by Dr Karl Deisseroth, Professor of Bioengineering and Psychiatry at Stanford University, turned mice – known for being highly-strung creatures – into bold explorers. A flashing blue light was shone on a specific circuit in their amygdalas using implanted optical fibres – the amygdala being a brain region involved with processing emotions.

But mucking about with genes in humans is ethically provocative – we don't even like GM food, let alone GM people. Besides, visible light can't penetrate the skull, so in many species optogenetics requires the skull to be opened. So at least in the short term, this technique is likely to remain the preserve of research, helping to pinpoint which neural circuits are behind which disease.

That said, could optogenetics actually be used to control the human brain and meddle with someone's personality? "Well, of course this would be completely unethical, but I'm convinced it's highly



Rats in Brazil and the USA had electrodes implanted in their brains, enabling them to communicate by thought

BRAIN CHANGERS

The key drugs that have been investigated for mind control

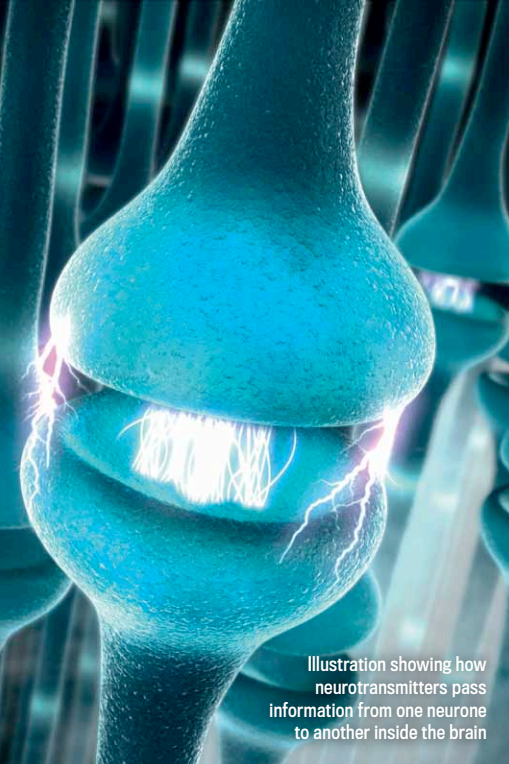


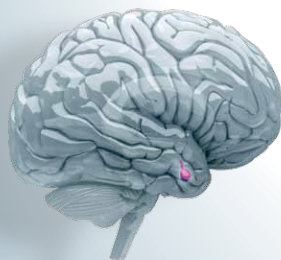
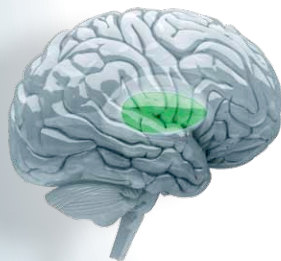
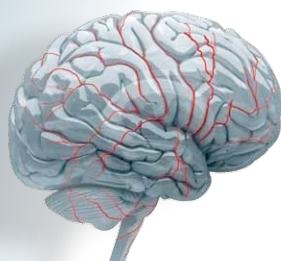
Illustration showing how neurotransmitters pass information from one neurone to another inside the brain

doable,” says Vanduffel. “Once we have a better understanding of the neural circuits involved you can artificially alter the activity of the neurones and change the behaviour and actions of people. To some extent this is already being done with deep brain stimulation.”

MENTAL STIMULATION

In deep brain stimulation (DBS), metal electrodes are implanted inside the brain to retrain circuits using electrical impulses. It’s already being used to treat patients with conditions ranging from chronic pain to Parkinson’s disease. “DBS seems to be able to reprogram faulty brain networks,” says Dr John Stein, Emeritus Professor at the University of Oxford. But the underlying mechanisms are still not clear.

Brain stimulation can even be used to extend existing senses. Dr Miguel Nicolelis and his team at Duke University in the US have devised a way to give mice the ability to sense infrared light. The rodents were fitted with electrodes linked up with the brain region that processes tactile signals received by the whiskers. At the other end of the electrodes was an infrared sensor. When exposed to infrared, the electrode sent a signal to their brains – in effect the mice were given the ability to ‘touch’ infrared light. “There seems no reason that these animals in the future could not be given full-fledged infrared vision,” says Nicolelis. And there seems



LYSERGIC ACID DIETHYLAMIDE (LSD)

LSD came to dominate many MKULTRA research programmes, but its effect on the brain is still not completely understood. It is thought to affect receptors for **serotonin**, a neurotransmitter responsible for regulating moods and sexuality – inhibiting some and blocking others. As a method of mind control, however, MKULTRA showed it to be ineffective.

MODAFINIL

Developed to treat narcolepsy, it’s also helping non-narcoleptics (including students and International Space Station crew members) stay awake and alert. The military, including the UK’s MOD, have been funding research into it. Exactly how it works is not clear – some scientists say it increases the production of **glutamate**, the brain’s energy chemical, exciting neurones across the brain.

OXYTOCIN

This is a hormone that can make people more sociable, but only if they already see those around them as people like them. If not, oxytocin can increase hostility. Potentially useful for boosting group bonding in combat units, its application in winning the hearts and minds of the enemy is more doubtful. It particularly affects social areas of the brain, including the **amygdala**, that are involved with processing emotional reactions.

SCOPOLAMINE

Used to treat nausea after operations, the US Navy and NASA are developing a nasal spray containing this chemical that could treat motion sickness. In higher doses it is said to make people more suggestible, and during the Cold War era it was used by the Czechoslovakian secret police to get confessions. It causes a reduction in activity in the **thalamus**, a brain region involved in the regulation of alertness, and in the cingulate cortex, a region involved with memory.

DEHYDROEPIANDROSTERONE (DHEA)

This steroid released by the adrenal glands could act as a stress-buster. It stimulates the **pituitary gland** to release stress hormones as well as affecting receptors in the brain which react to those hormones, reducing the effects of stress on the brain. Research on military personnel done in 2009 at the US National Center for Post-Traumatic Stress Disorder in Connecticut linked higher blood DHEA levels to better performance in stressful tasks.

HOW TO MANIPULATE A MIND

Three ways to influence someone that are far simpler than drugs or brain implants



INCENTIVES

This is the oldest trick in the book: give your target reasons to do what you want. This doesn't have to involve money: sometimes praise, a sense of belonging, even a smile can work as well or better than cash, as can negative social emotions like shame. Letters sent out by Her Majesty's Revenue and Customs (HMRC) that said most people had already paid their tax achieved 15 per cent higher payment rates. The UK government's new Behavioural Insights Team, or 'nudge unit', works on this principle.



UNSEEN CONTROL

When someone thinks about a belief, their brain is active in a particular pattern. When they're not thinking about it but still believe it, that pattern is stored in networks of neurones, which strengthen when activated by a stimulus and weaken when not used. One way to exert influence is to trigger the beliefs you want in someone by ensuring the right stimuli are present in their environment. But make this seem natural: a viral video or a casual remark work better than blatant advertising or instruction.



SUBTLE CUES

Most of what our brains detect, we never notice. You can use this to make yourself seem more likeable and boost your influence. At work, for example, subtly mirroring colleagues' body language can make you seem more similar to them, which they'll like – as long as it's done subtly! They'll also be cued not only by how you look, speak and dress, but by how warm and well-lit your office is, whether or not there are potted plants, whether you offer your visitors a hot drink and how your desk is positioned.

→ could not add senses to the human repertoire – perhaps the ability to 'taste' radio waves or 'smell' infrared light.

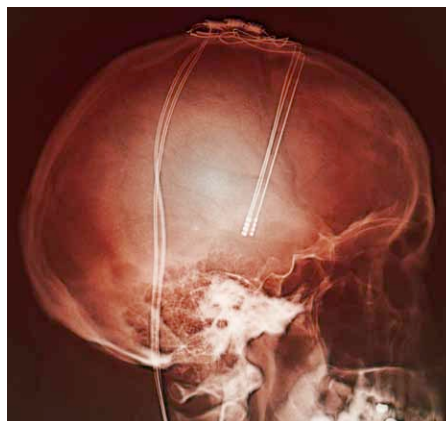
Nicolelis is also behind research, published earlier this year, in which rats with electrodes implanted in their brains were able to communicate with each other through brain signals, even though they were thousands of miles apart. One rat at Duke University, USA transmitted information to another at the University of Natal, Brazil about which switch to press to get a reward. Nicolelis, whose research is funded by the Pentagon's Defense Advanced Research Projects Agency (DARPA), foresees a time when many connected brains could be similarly linked to think through a problem.

"In theory, you could imagine that a combination of brains could provide solutions that individual brains cannot achieve by themselves," he says.

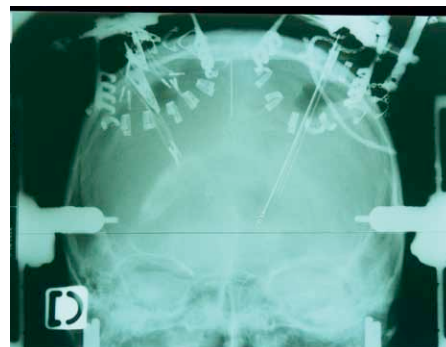
Both optogenetics and DBS are pretty invasive – requiring

6

per cent of the CIA's budget was allocated to MKULTRA in 1953, the year it was officially sanctioned



These images show DBS being used to treat Parkinson's disease, but it may also have potential for mind control



wires to be implanted in the brain. But what if the brain could be controlled without the need for implants? Biomedical engineer Dr William Tyler at Virginia Tech Carilion Research Institute in the US is investigating the use of pulses of ultrasound that can travel through the skull into the brain to stimulate circuits.

Ultrasound is most commonly associated with medical scans, but if the frequency and intensity of the sound waves are tweaked it can stimulate specific brain regions. It does this with an accuracy comparable to DBS – the waves can be focused on an area of 1 to 3 cubic millimetres. The dream is to be able to use ultrasound to treat conditions such as depression and epilepsy or even boost working memory and creativity.

In the long term, the ultrasound research could even lead to ballistic helmets for soldiers that provide navigational commands, improve long-term alertness and reduce anxiety.

MYSTERIES OF THE BRAIN

But the effectiveness of any mind control technique depends on knowing exactly which brain regions to stimulate to



Dr William Tyler's lab is working on non-invasive ways to control the brain

44

US colleges and universities, 12 hospitals and clinics, and three prisons participated in MKULTRA

Gero Miesenböck, Professor of Physiology and Director of the Centre for Neural Circuits and Behaviour at the University of Oxford.

As *Focus* went to press, the Obama administration was expected to announce

produce the desired effect – and our map of brain function is still decidedly foggy. Some neuroscientists believe this could be a major stumbling block in years to come. “We simply don’t know enough about the neural basis of most human behaviour, motivations or beliefs to make targeted interventions yet,” says

“The effectiveness of any mind control technique depends on knowing exactly which brain regions to stimulate”

a decade-long research project aimed at building a comprehensive map of the brain’s activity that ties actions and thoughts to specific brain regions. The Brain Activity Mapping Project is the brain equivalent of the Human Genome Project

and is expected to cost more than \$300 million per year over 10 years.

Before neuroscientists start their cerebral cartography, they need to develop the tools required for probing our minds. Designing tiny sensors able to enter neurones and record their activity will be central to the project’s success. Despite the hurdles, the pay-offs could be huge. “The more we know about how the brain functions, the more efficient the development and design of possible therapies will be,” says Vanduffel.

But as our knowledge of the activity of the brain grows and our techniques of mind control become ever more sophisticated, even a person’s deepest convictions will become susceptible to the tools of brain manipulation. In the hands of a state with a cause to propagate, this could be a dangerous weapon. MKULTRA may be dead, but the age of mind control could be just about to begin. ■

KATHLEEN TAYLOR is the author of *The Brain Supremacy: Notes From The Frontiers Of Neuroscience* (OUP, 2012)

Find out more

The Search For The Manchurian Candidate: CIA And Mind Control
By John Marks (WW Norton, 1992)

<http://bit.ly/YnjhtC>

Details of DARPA's current neuroscience research



Mapping how neurones interact could lead to more advanced mind control techniques

THE NORTHERN LIGHTS

The Northern Lights are one of nature's great displays: a mysterious, multicoloured show in which the night sky is spectacularly lit up with a wondrous glow that twists and swirls. It's one of the great, timeless thrills of travel, a beautiful dance of natural light that many viewers find a humbling and spiritually uplifting experience.

Since the aurorae occur most commonly in the polar regions, the chance of enjoying this breathtaking natural spectacle has become one of the prime reasons to travel to these regions. The good news is that the extensive range of holidays available for avid and enthusiastic spectators of the Northern Lights has never been better.

Here is a selection of some of the most desirable Northern Light holidays. The strength of auroral activity runs in 11-year cycles; 2013 / 2014 just happens to be one of the peak moments known as the 'Solar Maximum', with experts predicting plentiful and spectacular displays. If you have always wanted to see the Northern Lights, undoubtedly, the time is now.

PROBABLY THE BEST PLACE ON EARTH FOR SEEING THE AURORA BOREALIS



Auroral Corona Abisko 04 March 2013



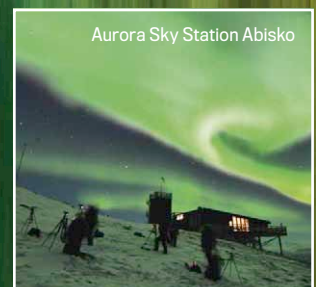
The Solar Maximum has created 'Northern lights fever' as travellers flock to witness the aurorae in their full glory. When planning a holiday to the Arctic, it pays to know where to go.

Weekend a la Carte introduce the Aurora Sky Station in Abisko Swedish Lapland to Northern Lights hunters and have watched as it claimed its place as one of the best viewing locations on earth. With a strike rate of 70-80% of our clients witnessing the aurorae, we know of nowhere better!

We offer a range of breaks that have been crafted over 10 years to bring you all the traditional Arctic Experiences, including photo workshops with Chad Blakely, renowned 'Lights over Lapland' photographer. The featured photos were taken with clients on nights out.

Contact Kevin of Hannah to enquire about our Northern Lights holidays on the number/website below.

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Aurora Sky Station Abisko



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Is 2013/14 the best year ever for the Northern Lights? Amazing, magical, wonderful, awe inspiring, mesmerising and enchanting are just some of the words to describe these colourful ribbons of light in the night sky. With one of the largest selections of tailor-made holidays, Simply Sweden is one of the leading providers of Northern Lights Holidays to Sweden and Norway! We strongly recommend booking early to avoid disappointment.

The spectacular Northern Lights are one of Mother Nature's magical treats and never fail to amaze. We can't guarantee you will see the Northern Lights, however we can take you to some of the best places on Earth to see them. These beautiful locations include Lapland, the world famous and original ICEHOTEL, the Abisko Mountain Valley, the Lofoten Islands, Tromsø and Northern Norway.

Photos © Simply Sweden.



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EXPERIENCE THE NORTHERN LIGHTS IN ICELAND

With the whole country located within the all-important Northern Lights oval, Iceland affords superb opportunities to experience the elusive Aurora Borealis. And with a spectacular backdrop of thundering waterfalls, bubbling geysers and creaking glaciers, catching a performance of the magical light show is just one reason to choose a winter holiday in Iceland.

Specialists in travel to Iceland and Greenland for 38 years, Regent Holidays can create the perfect Northern Lights holiday for you, whatever your timeframe or interests.

For a winter city break with a difference, travel to Reykjavik and combine a Superjeep Northern Lights Hunt with whale watching from the historic harbour and sipping a cocktail in the famous Blue Lagoon. Those looking for a romantic escape may choose to head to a wilderness lodge where it's possible to relax in a geothermal hot tub as the aurora brings dancing ribbons of colour to the night sky overhead. For travellers with more time, opt for an escorted tour such as Regent's 8-day Northern Lights Explorer or Northern Lights Photography Tour, where a daytime discovery of Iceland's stunning natural wonders is complemented by evening presentations, lectures and guided tours at spots likely to offer a glimpse of the aurora.

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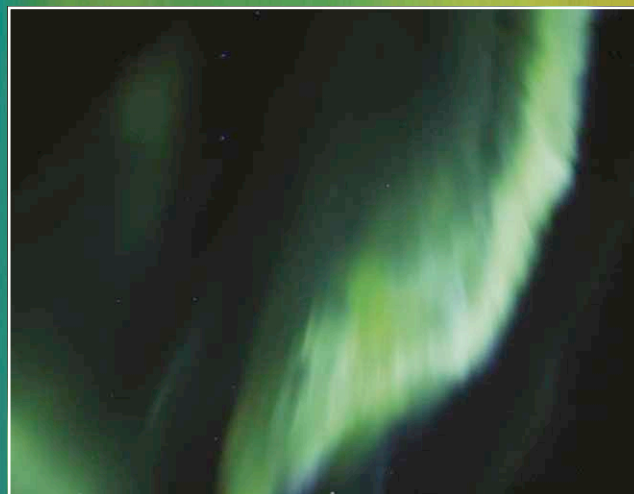
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Q&A

YOUR QUESTIONS ANSWERED

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Susan is a visiting psychology professor at the University of Plymouth. Her books include *The Meme Machine*



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Alastair is a radio astronomer at the Jodrell Bank Centre for Astrophysics at the University of Manchester



ROBERT MATTHEWS

After studying physics at Oxford, Robert became a science writer. He's a visiting reader in science at Aston University



GARETH MITCHELL

Starting out as a broadcast engineer, Gareth now writes and presents *Digital Planet* on the BBC World Service



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Luis has a BSc in computing and an MSc in zoology from Oxford. His works include *How Cows Reach The Ground*

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Do you look overweight? Have a face that consists of a single orifice? Can you survive being boiled? Then you qualify for Waterbear Extreme Life Insurance

Q MELANIE O'BRIEN, LONDON

What's the world's toughest animal?

A THE HANDS DOWN hardest creature is a tardigrade, also known as a waterbear. Less than 1.5mm long, they can dehydrate their bodies to just 1 per cent of their normal water content. Without water, most chemical reactions happen too slowly to harm them and ice crystals can't rupture their cells. They are extremophiles – animals that can exist in the most hostile of conditions.

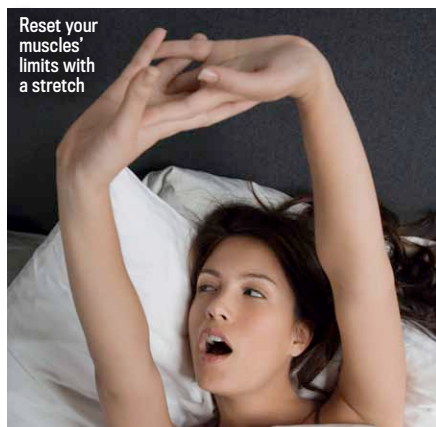
Tardigrades have been boiled at over 150°C and frozen in liquid nitrogen without any noticeable harm. They can survive pressures of 6,000 atmospheres and in 2007, the Russian FOTON-M3 spacecraft took tardigrade passengers into orbit. After 12 days exposed to the vacuum, cold and radiation of space, they hadn't just survived; they had laid eggs that hatched! **LV**

PHOTO: SCIENCE PHOTO LIBRARY

Q SOLANG UK, SWITZERLAND

Why do we stretch when we wake up?

A WHEN YOU SLEEP, your muscles lose tone and fluid tends to pool along your back. Stretching helps to massage fluid gently back into the normal position. Also, your muscles protect themselves from over-extension by inhibiting the nerve impulses as they approach their limit. Over time, this safety mechanism becomes increasingly restrictive. Stretching briefly takes your muscles outside their normal range. This recalibrates the feedback mechanisms that determine their normal amount of motion. **LV**



Reset your muscles' limits with a stretch

Q JULIA VELLA, MALTA

Why does cornflour suddenly turn solid when poked?

A MIX SOME CORNFLOUR with water until it's like single cream, and you'll find that if you jab it with a finger, it turns solid, but goes gooey again when treated more gently. Called 'dilatancy', it's the result of the sharp-edge grains of cornflour piling up like speeding cars in busy traffic, which don't give themselves time to manoeuvre round each other without colliding. **RM**



Cornflour grains don't like being poked around

Q RON GARDNER, SHROPSHIRE

Could a new species of human evolve?

A MODERN MEDICINE AND the comforts of civilisation have changed the way that natural selection affects us, but we haven't yet wriggled entirely free of its grasp. But no matter how the human race continues to evolve, it will still be the same species. For humanity to split into a new species, we would need to become reproductively separated. Otherwise, the genes just get mixed back in again. Earth is too small for geographical or cultural barriers to prevent different nations and races from interbreeding. We'd need to colonise Mars or another planet with a community that remained separate for hundreds of generations before a separate species formed. **LV**



The inhabitants of a future Mars, terraformed to make it habitable, could become an entirely separate species to us Earthlings

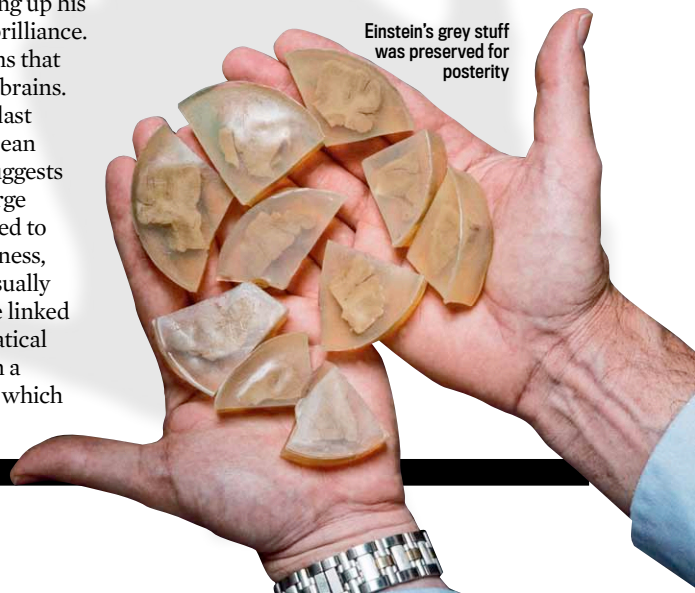
Q KHANAL KAPIL, BY EMAIL

How do the brains of intelligent people differ from others?

A WHEN ALBERT EINSTEIN died in 1955, doctors couldn't resist opening up his brain and looking for clues to his brilliance. And what they found backed claims that really smart people have different brains. The most recent study, published last November by a team led by Prof Dean Falk at Florida State University, suggests Einstein's brain had a relatively large prefrontal cortex – the region linked to the highest functions of consciousness, like imagination. He also had unusually shaped parietal lobes, known to be linked to visual-spatial skill and mathematical ability. These were combined with a high density of so-called glial cells, which

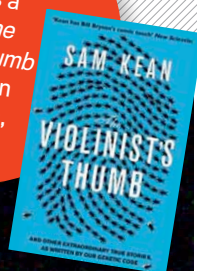
feed the neurones needed for thought. So Einstein's brain seems well-suited to making amazing discoveries.

Studies searching for similar differences among the general population have come up with intriguing results too. For instance, brain scanning research has shown a link between intelligence and the quantity of brain cell nuclei, known as grey matter. **RM**



Einstein's grey stuff was preserved for posterity

QUESTION OF THE MONTH

WINNER!Colin wins a copy of *The Violinist's Thumb* by Sam Kean (Black Swan, £8.99)

Pictured here by the Hubble Space Telescope, 1 Zwicky 18 is thought to be the youngest galaxy ever seen, at only about 500 million years old

Q COLIN BUTTON, HALSTEAD

Are new galaxies still forming?

A IT APPEARS THAT new-born galaxies are alive and well in the Universe. Most galaxies formed very soon after the Big Bang and astronomers have known for some time that the rate of galaxy formation has steadily declined through time. When the Universe was young, galaxies were forming regularly, but over time fewer and fewer were born as these babies grew up into adult galaxies much like our own Milky Way.

Recently, however, astronomers have found evidence that both dwarf galaxies and their more massive cousins are still forming in the Universe. Some may be younger than 1 billion years. These galaxies seem to have remained in an embryonic state as cold clouds of hydrogen and helium gas for most of the Universe's history. Why they took so long to form into galaxies, and what it was that made them do so, is currently unknown. **AG**

'I need my glasses to read this article on sneezing'



Q JONO HEY, LONDON

Why does looking at a bright light help you sneeze?

A IT'S CALLED THE 'photic sneeze' but only about one in three people experience it. The exact mechanism isn't known, but it may be that bright lights stimulate the branch of the large trigeminal nerve that runs to the eye and that some of this stimulus crosses over to the branch that connects the nose. **LV**

Room with a view: enjoy a sunset or sunrise every 45 minutes on the ISS



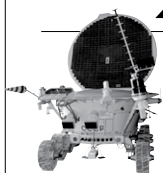
Q RICHARD O'NEILL, GLASGOW

What time zone do they use on the International Space Station?

A INTERNATIONAL SPACE STATION crews experience a sunset or a sunrise every 45 minutes. New members arrive acclimatised to Kazakhstan time, having departed from the Baikonur Cosmodrome. With so much scope for chronological confusion, it's no wonder that the ISS needs to be locked to a consistent time. The zone of choice is Coordinated Universal Time (UTC), which is equivalent to GMT. **GM**

TOP TEN

DISTANCES TRAVELLED ON OTHER WORLDS BY ROVERS



1. Lunokhod 2

37km

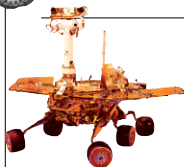
1973, USSR



2. Apollo 17 Lunar Rover

35.8km

1972, NASA



3. Opportunity

35.5km

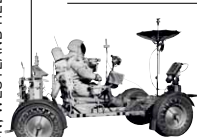
2004-present, NASA



4. Apollo 15 Lunar Rover

27.7km

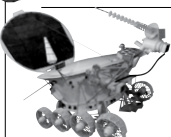
1971, NASA



5. Apollo 16 Lunar Rover

26.5km

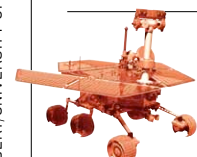
1972, NASA



6. Lunokhod 1

10.5km

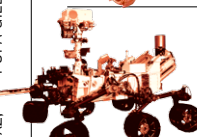
1970, USSR



7. Spirit

7.7km

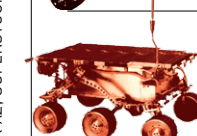
2004-2010, NASA



8. Curiosity

0.7km

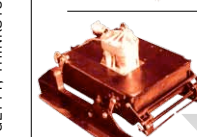
2012-present, NASA



9. Sojourner

0.5km

1997-1998, NASA



10. Prop-M

0km (crashed)

1971, USSR

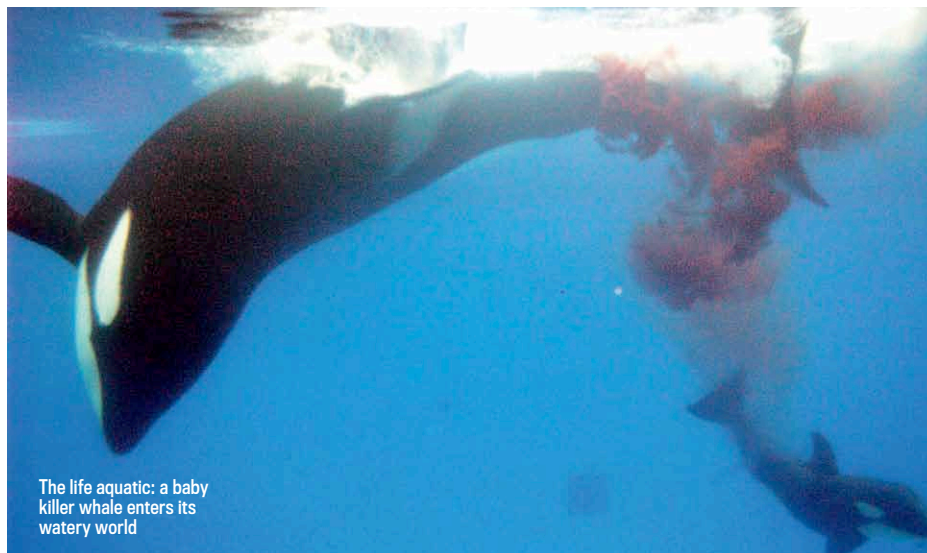


MARS MISSION



MOON MISSION

PHOTO: GETTY, THINKSTOCK X2, SUPERSTOCK X2, PUPA GILBERT/UNIVERSITY OF WISCONSIN-MADISON, WESTLAND HELICOPTERS



The life aquatic: a baby killer whale enters its watery world

Q SALLY MELLISH, HEREFORD

Do whales have belly buttons and nipples?

A THEY DO INDEED. Whales and dolphins are mammals, which means that although they live in water, they are warm-blooded, breathe air, give birth to live young and have mammary glands producing milk. Young whales are born underwater and have an umbilical cord just as we do. When the cord is broken after birth the scar left behind becomes

the belly button. The calf then drinks milk from its mother's nipples which are usually hidden within a 'mammary slit'. In some species the mother squirts the milk into the calf's mouth. This is possible underwater because whale milk is very thick, having a fat content of between 35 and 50 per cent and a consistency like toothpaste.

Mother killer whales have been seen feeding their young in captivity. The mother glides in a horizontal position and the calf swims on its side as it sucks from her nipple. **SB**



Looking like something the A-Team would fly, the Westland Lynx is officially the world's fastest chopper

Q LOUIS GOODWIN, LEWES

What's the fastest helicopter in the world?

A OFFICIALLY, THE WORLD'S fastest chopper is the Westland Lynx, a multi-purpose military aircraft that has seen naval and battlefield use. In its record-breaking flight in 1986, a Lynx helicopter flew a 15km course in Somerset near the Yeovil factory where it was manufactured. Over two legs, the aircraft managed an average of 400.9km/h.

However in July 2010, the Sikorsky X2 helicopter beat the Lynx, achieving 417km/h in a test flight. The Sikorsky is a distinctive beast with an inverted tail and coaxial rotors. There are two rotors, each with four blades mounted one above the other, rotating in opposite directions. There is also a six-bladed propeller at the rear. This configuration is designed to increase speed and to usher in the next generation of super-fast military and civil helicopters. However, there was no observer from the National Aeronautic Association to witness the Sikorsky flight, so the Lynx's record still stands. **GM**



Q JACK HEMMINGS, BY EMAIL

The release of the wrist-cuckoo clock was a watershed moment for retro watch enthusiasts

Are digital clocks more accurate than analogue clocks?

A IN FACT ANALOGUE clocks are more precise than digital ones. But they are not necessarily more accurate. That might seem contradictory, but the sweep of the hands on an analogue clock is continuous, whereas a digital clock is

governed by fixed values. Therefore, an analogue clock can show a precise time. A digital timekeeper approximates to an interval determined by the number of digits on its display. So it can be more accurate, but it is less precise. **GM**

WHAT IS THIS?



KNOW THE ANSWER?

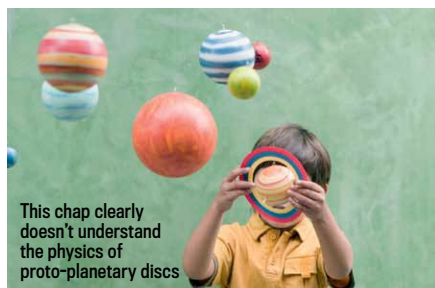
Go to sciencefocus.com/qanda/what and submit your answer now!

LAST MONTH'S ANSWER:

Well done to Phil Atkins, who correctly guessed a circumhorizontal arc.

Q JACK WALKER, WEST YORKSHIRE

What determines how big a planet is?



This chap clearly doesn't understand the physics of proto-planetary discs

A A PLANET'S SIZE is determined by how much material it was able to accumulate during its formation. The inner parts of the proto-planetary disc around the new-born Sun, from which the planets formed, were too warm for lighter molecules (like water and methane) to condense, giving rise to rocky planets with heavier elements. The gas giants formed further out where these lighter (or volatile) materials could condense more easily. Since volatile compounds were more abundant than heavier elements, the outer planets grew much larger. **AG**

? Did you know?

The hottest place in the Solar System is in the core of the Sun, at around 15,600,000°C.



Q SIMON MARKS, OXFORD

Why do our fingers wrinkle in the bath?

A IT USED TO be thought that wrinkling was a purely passive process, caused by your fingers absorbing water so that the skin swelled up and became too big for the tissue it was anchored to. In fact, recent research has shown that it's the other way around: the tissues of the fingertips contract and pull the surrounding skin into wrinkles. This is an active mechanism controlled by the nervous system. Since your body is deliberately wrinkling your fingers, that suggests there must be a reason for it and a recent study at Newcastle University showed that wrinkled fingers are better at gripping wet objects. As well as allowing our ancestors to grapple with wriggling fish, this would have helped them to keep their balance on wet rocks because our toes get wrinkly too. **LV**

Q JACK HEMMINGS, BY EMAIL

Why do candles only smoke after they've been extinguished?

A SMOKE IS UNBURNED particles of carbon released when the hydrocarbon chain of candle wax breaks down. When the candle is alight, most of the carbon gets burned to carbon dioxide, but some escapes. If you hold a plate above a candle flame, you'll see the carbon accumulate as a sooty smear. When the flame goes out, the glowing wick has enough heat left to break up the wax molecules for a while, but not enough to burn the carbon, so you get a trail of smoke until it cools. **LV**



Q CARLA REDHEAD, WEYMOUTH

How do infrared TV controls work?

A INFRARED remotes send a binary signal encoded with a command. Instructions to change the channel or adjust the volume are usually encoded in a seven-bit code. Added to that is a device identifier so that the commands act on the television rather than, say, your set-top box. The command is converted into the invisible flashing of your remote's LED in one of three ways: pulse, space or shift-coded. In the former, the duration of the light pulse represents the binary bit. For instance, a long pulse could be a '1' and a short pulse, a '0'. Space-coded is the same, only the space between pulses carries the binary bits. Shift-coded is where the television detects what the pulse is doing at regular intervals in time. The LED going from off to on during one of those intervals, or on to off, carries the desired bit of code. **GM**

Q LUKE AZZOPARDI, MALTA

Are all fermented drinks alcoholic?



Fermentation tanks brew man's greatest invention: red wine

A YES, BY DEFINITION, fermentation is the process of turning sugar into alcohol by the metabolic action of yeast, or sometimes bacteria. However, the alcohol can be removed *after* the fermentation process.

Alcohol boils at 78.3°C, rather than 100°C for water, so you can remove the alcohol by heating the drink – distilling it essentially, except that you keep the part that is left behind, instead of the vapour that boils off. Vacuum evaporation is usually used to create alcohol-free beer and wine, rather than heating, to avoid cooking the drink and affecting the desired taste. **LV**

Q PHIL HARPER, LEEDS

What's the best way to beat arachnophobia?

A EXPOSURE THERAPY IS probably the most successful. Arachnophobia (from the Greek for spiders and fear) affects roughly half of women and one in 10 men. It may even be an instinctive response, evolved among our ancestors to avoid dangerous species. Arachnophobes often think about spiders and avoid situations where spiders may lurk, or even where they may see pictures or videos of them. This strategy only increases their fear.

Effective treatment begins with information about how spiders behave, how fragile they are, and facts about the very few that can harm us and the majority that cannot. Relaxation training helps the patient learn to relax

before they are gradually exposed to ever more realistic spiders. They may begin with webs and very distant photos of spiders, gradually progressing to closer and more realistic ones. Virtual reality spiders in different settings can help, until finally the arachnophobe is introduced to the real thing. They may even end up able to handle enormous tarantulas and forget their fear completely. **SB**

Arachnophobia must be horrible when you turn a page to see life-like spiders...



Q PETER YOUNG, FOREST ROW

Why do planes appear to travel so slowly in the sky?

A OUR BRAINS JUDGE the speed of objects passing by us through the time taken for them to cross our field of view. Those taking a long time could either be nearby and travelling slowly or faster and further away. And in the case of planes, our brains know that the second interpretation is the right one. **RM**



The need for a third runway became paramount



HOW IT WORKS

MIND-CONTROLLED ROBOTIC ARM

IT MAY SOUND like a concept from a science fiction film, but in December last year researchers at the University of Pittsburgh pulled off a remarkable feat: the operation of a robotic arm with mind control alone. Two tiny arrays of 96 electrodes were implanted just beneath the surface of the brain of 52-year-old quadriplegic Jan Scheuermann. The electrodes fed information from her brain to a robotic arm, which she could manipulate in real-time by simply thinking about doing so.

To give Jan control of the arm, doctors first recorded her mental activity using an fMRI scanner as she imagined moving her arm. This enabled them to place the electrodes on the part of the brain that was active when thinking of arm movement, in the motor cortex. The electrodes penetrate into the brain and are able to pick up the activity of individual neurones. Computer algorithms were then used to identify the different patterns of firing neurones associated with various imagined arm movements. When the system was connected to the robotic arm, these movements were then translated into a corresponding action.

Two arrays of electrodes are implanted in the motor cortex and pick up signals from individual neurones before passing them to a connector on the skull.

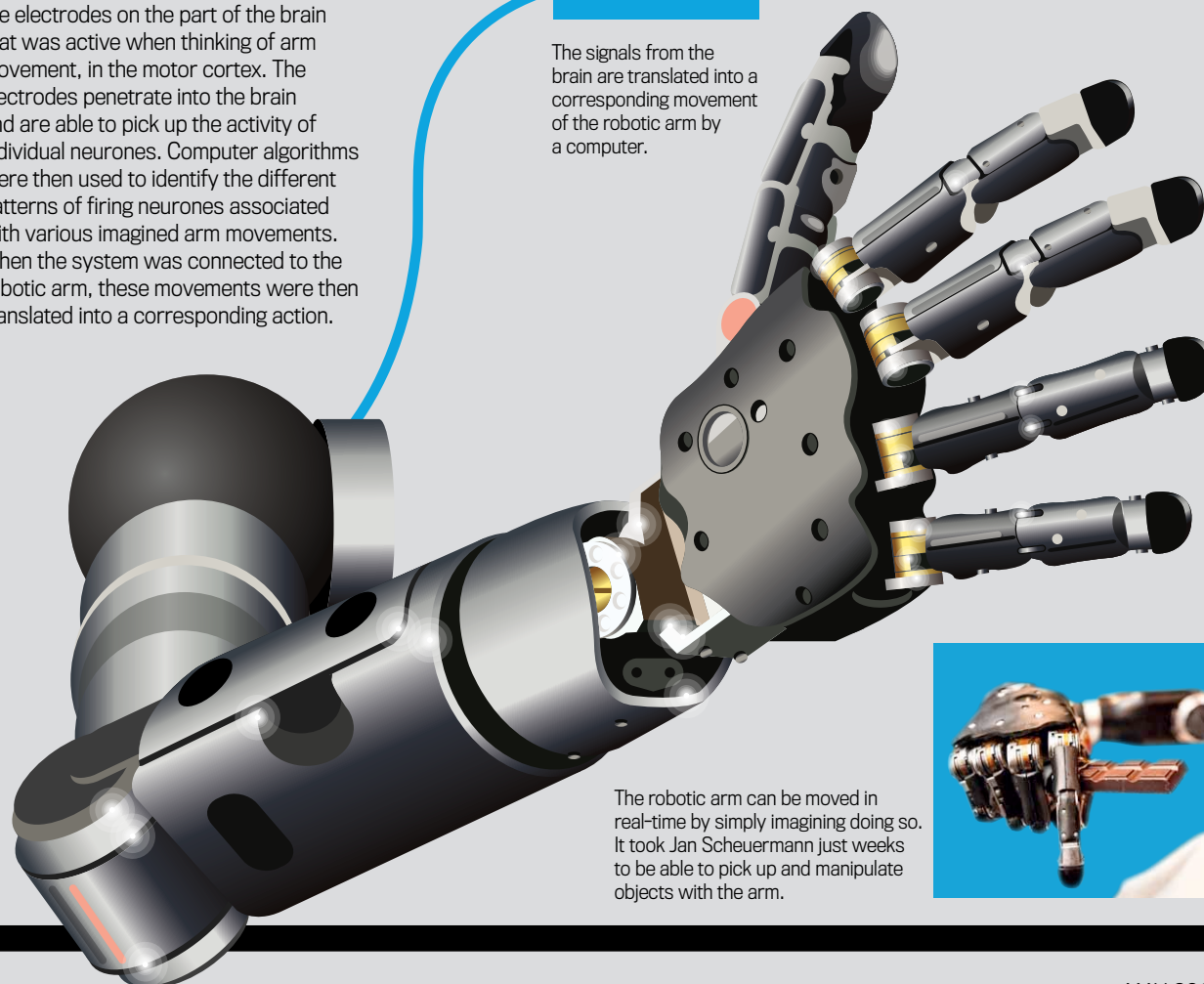
CONNECTOR

MICROELECTRODE ARRAY

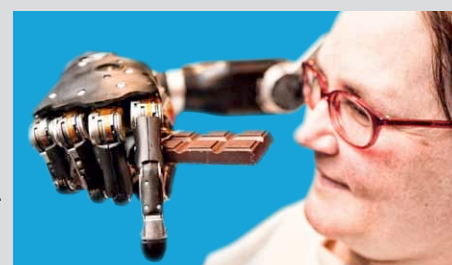
4mm

BRAIN-MACHINE INTERFACE

The signals from the brain are translated into a corresponding movement of the robotic arm by a computer.



The robotic arm can be moved in real-time by simply imagining doing so. It took Jan Scheuermann just weeks to be able to pick up and manipulate objects with the arm.



THE NIGHT SKY: WHAT CAN I SEE IN MAY?



Don't miss *The Sky At Night* on BBC One every month
www.bbc.co.uk/skyatnight

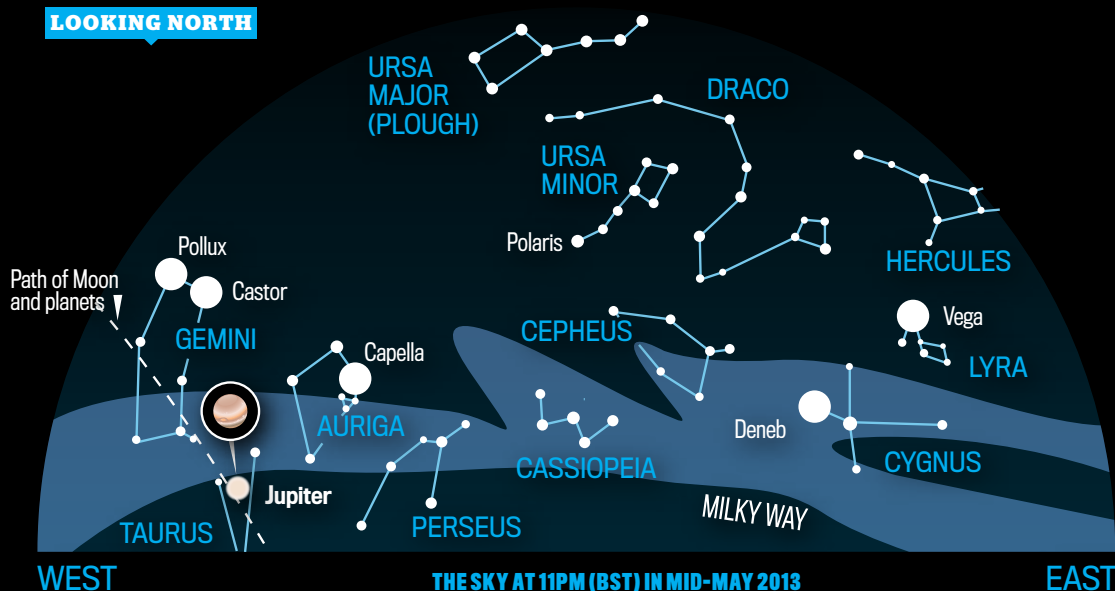
Astronomy with
 Heather Couper
 and Nigel Henbest



THE WINTER STARS are now banished, with only the constellations of Gemini and Auriga clinging to the western horizon. The summer constellations are starting to appear, as Earth travels on its carousel ride around the Sun. Mighty Jupiter is also about to exit the celestial stage this month, setting at around 11pm. Its fellow gas giant, Saturn, is still a brilliant object in the southern skies, close to the boundaries of Libra and Virgo. And there's a meteor shower on offer too!

LOOKING NORTH

OVERHEAD



LOOKING NORTH

All month, evening

Now is a good time to pick out the Plough, sailing overhead. Five of its stars (with the exception of the two end ones) are travelling together through space as a 'stellar association' – stars that were born together.

**11 May, 9.30pm and
 12 May, 10pm**

Look out for the crescent Moon next to Jupiter and Venus on 11 May. Next evening, it makes a glorious pair with Jupiter.

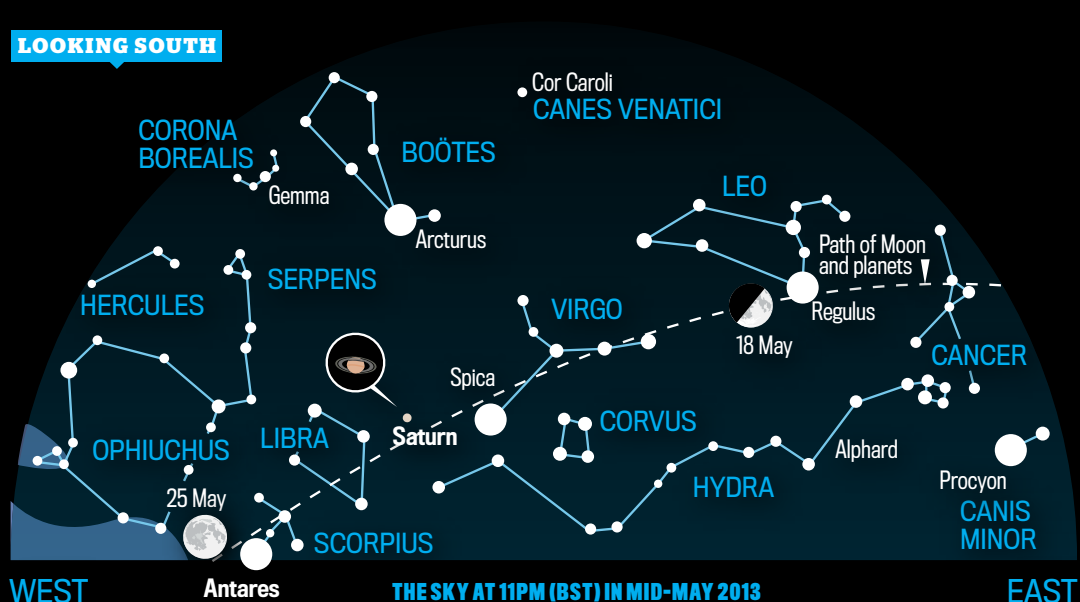
LOOKING SOUTH

5-6 May, best after midnight

Halley's Comet reappears in the form of the Eta Aquarid Meteor Shower! These fragments from the comet hit Earth's atmosphere and burn up. On a clear night, expect to see around 40 shooting stars an hour.

LOOKING SOUTH

OVERHEAD



All month, evening

Summer is truly on the way when the orange-coloured star Arcturus makes an appearance in our skies. It's the fourth brightest star in the heavens. A red giant, near the end of its life, Arcturus shines more than 100 times brighter than the Sun.

Find out more

**Sky at Night
 Magazine**

On sale now,
 priced £4.75



Q RACHAEL EDWARDS, ANDOVER

Does asparagus help a hangover?



A WHILE ALCOHOL IN your blood can make you feel good, the breakdown products give you a hangover. When you drink alcohol (ethanol), the enzyme alcohol dehydrogenase in your liver converts it to acetaldehyde (ethanal). Then acetaldehyde dehydrogenase takes over and turns the ethanal to acetate, before it's broken down into carbon dioxide and water.

Asparagus contains compounds that more than double the speed of both the alcohol and acetaldehyde dehydrogenase enzymes. If you took asparagus before you went out for the night, this would reduce

how drunk you felt because the alcohol would be processed more quickly. Taken the morning after, it would also help to mop up any remaining ethanal in your blood. The downside is that a bottleneck is created that will increase the levels of acetate. This causes the chemical adenosine to accumulate in your brain, which lowers the activity of your brain cells. This is why a hangover also makes you feel sluggish. Luckily, caffeine binds to the same receptors as adenosine, so a cup of coffee prevents the adenosine from slowing you down. **LV**

Q ANDREW HOLMES, NORTHUMBERLAND

What causes the 'heavy' sensation of a dead arm?



A USUALLY IT'S RESTRICTED blood flow. This often happens during sleep if you turn into an awkward position and squash the arteries running down your arm. When the flow of blood is reduced, muscles, nerves and other tissues are deprived of oxygen and nutrients. When nerves are affected this causes numbness as well as tingling or burning sensations that can wake you up.

If you then try to move, your arm feels heavy. This is because the muscles are weakened by lack of blood. So even if you make a big effort, the arm does not move normally. The same effect can be caused by wearing a rucksack with the straps not properly adjusted or indeed by anything that stops adequate blood flow to the arm. If you have persistent 'dead arm' this may be due to injury or disease and needs medical advice. **SB**

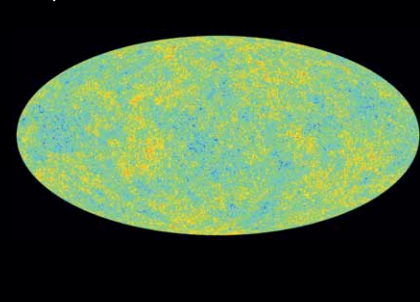
We like to take things literally here at Focus

Did you know?

The oldest island is Madagascar in the Indian Ocean. It broke off from the Indian subcontinent about 80-100 million years ago.



The Cosmic Microwave Background has enabled us to slap a date on the Universe



Q DAN BROMLEY, BY EMAIL

How do we know the age of the Universe?

A CURRENTLY, THE BEST estimate for the age of the Universe is 13.772 billion years, with an error of plus or minus 59 million years. We've arrived at this figure by measuring the current rate of expansion of the Universe and then extrapolating backwards. In practice, however, we also have to know how that expansion rate may have changed through time and this is dictated by the matter composition and energy density of the Universe.

Fortunately, this information is embedded in the tiny temperature fluctuations found in the Cosmic Microwave Background, the faint glow of light that fills the Universe and which is the residual heat left over from the Big Bang. NASA's WMAP satellite measured these fluctuations to an unprecedented accuracy, enabling astronomers to narrow down the age of the Universe to within 0.4 per cent. The WMAP results agree with other completely independent means of estimating the age of the Universe. **AG**

In Numbers

257,885,161-1

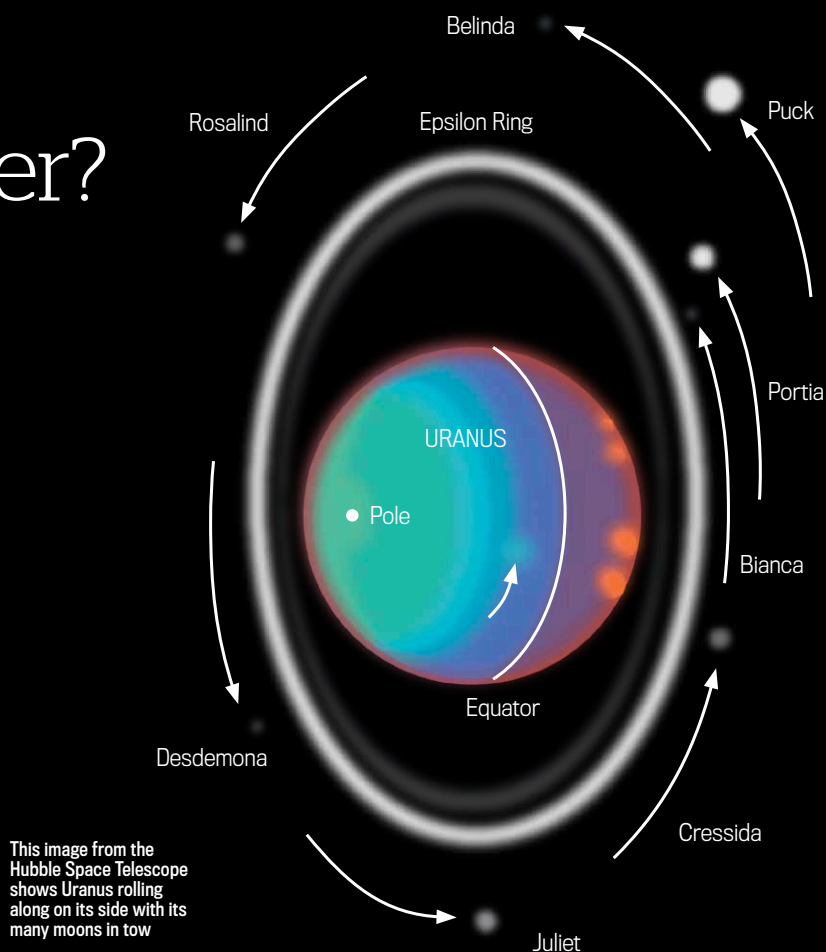
is the largest known prime number, with 17,425,170 digits. Numbers this large may have a future application in cryptography.

Q DENNIS FRASER, EXETER

Could the Earth flip over?

A THE IDEA OF Earth flipping over might seem ridiculous, but it's not impossible. The planet Uranus lies on its side, possibly after being struck by a giant rock in the early, turbulent history of the Solar System around 4 billion years ago. The bizarre backwards rotation of Venus suggests it has been flipped right over, although some astronomers argue it may have stayed upright, and just had its spin reversed through gravitational tugs from the Sun and planets.

Happily, the presence of our hefty orbiting Moon makes the Earth very resistant to such effects. But it could still be flipped over if struck by some suitably huge and fast-moving cosmic object. The sheer bulk of the Earth would require a very violent impact, though – and were it to happen, there's little hope that human life would survive; indeed the entire planet may be partially or completely destroyed. **RM**



This image from the Hubble Space Telescope shows Uranus rolling along on its side with its many moons in tow

Q JAMES BONTOLT, SKIPTON

How fast is a Wi-Fi network?

A MOST WI-FI networks operate on variants of IEEE 802.11, an internationally agreed standard for carrying digital data wirelessly. The first widely used type was 802.11b, offering a theoretical speed of 11 megabits per second (Mbps). One megabit is 1,000,000 bits of data a second. At that speed you could transfer a 1GB movie across your network in just over 12 minutes. My own router supports the later 802.11g standard allowing speeds of up to 54Mbps, or a 1GB movie to be transferred in two and a half minutes. However, interference and physical obstructions can interrupt the speed of the network. **GM**



Q MARK LUDWORTH, CHESHIRE

How do mosquitoes fly in the rain?



Not even a rain storm will keep these critters from bugging you

A BY GOING WITH the flow. A single raindrop can weigh 50 times more than a mosquito. Scaled up to human size, this would be like having a car land on a person. So why aren't mosquitoes squashed by the rain? Their tiny mass and very strong exoskeleton certainly help, but recent research with high speed video has revealed they have a cunning technique. Rather than resisting the drops, mosquitoes grab onto them. They then fall for up to 20 body lengths before separating from the front of the drop using their long legs and strong wings. This way they fly free of the drop before it hits the ground. **SB**

NEXT MONTH Over 20 more of your questions answered



For even more answers to the most puzzling questions, see the Q&A archive at www.sciencefocus.com/qanda

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MEGATSUNAMI

Are we in danger of a giant tidal wave causing mass destruction worldwide? **Bill McGuire** reveals how it's only a matter of time before such a surge is unleashed

RECENT EVENTS IN Japan and southeast Asia have ensured we are all too aware of the tsunami-triggering potential of enormous, submarine earthquakes. Less well known, however, is the fact that volcanoes are also very effective tsunami generators, with 'flank collapse' – when a sizeable chunk of a volcano collapses into the sea – spawning tsunamis that have taken close to 20,000 lives in the last 400 years.

In 1979 a tsunami caused by the collapse of Indonesia's Iliwerung volcano took several hundred lives. And in 1792, the failure of part of Japan's Unzen volcano launched a tsunami that battered coastal villages, resulting in 14,000 deaths. Now scientists say a collapse of the Cumbre Vieja volcano in the Canary Islands could create a tsunami that would devastate the East Coast of the USA and batter the UK's western shores. It's the subject of a new

BBC dramatisation called *Megatsunami*, airing this month on BBC Two.

More often than not, volcanoes are not solid, unmoving bastions of strength, but wobbly piles of ash and lava rubble just looking for an excuse to collapse. The evidence for this is all around us, with many hundreds of massive landslides now identified at volcanoes right across the planet. Typically, these leave behind enormous collapse scars, such as the great rocky amphitheatre torn from the east flank of Mount Etna and, most recently, the 3km-wide bite taken out of the north flank of Mount St Helens by the landslide that triggered its 1980 eruption.

SLIPPERY SLOPE

Once a volcano's flank has become unstable, it can be shaken off by an earthquake, pushed off by an injection of new magma, or sometimes just fall off as the flank becomes too steep. It doesn't even need an eruption



A tsunami triggered from a volcanic landslide could send a colossal wave crashing into the American coast



➔ to start things moving. As the extraordinary footage of the collapse of Mount St Helens north flank reveals, once a volcanic landslide gets going, there is no stopping it. The mass of moving rock hurtles downslope at velocities matching those of a Formula 1 racing car, typically travelling many kilometres before coming to rest and obliterating anything and everything in its path.

With a volume of a couple of cubic kilometres, the Mount St Helens landslide was just a tiddler. Compare this with the 45km³ prehistoric flank collapse at neighbouring Mount Shasta, or the staggering 5,000km³ volume of the Nuuanu landslide, which took an

enormous bite out of Hawaii's Ko'olau volcano a few million years ago.

But the Nuuanu landslide is just one of around 70 mammoth collapses whose debris is scattered about the sea floor surrounding the islands of Hawaii. Another, known as the Alike 2 slide, formed about 100,000 years ago when a monumental chunk of the Big Island's Mauna Loa volcano fell into the Pacific, sending a towering tsunami surging throughout the archipelago. Marine shell deposits now stranded up to 60m above sea level on the flanks of neighbouring Kohala volcano testify to colossal waves, but this is only half the picture. Over the last hundred millennia, the Kohala volcano has actually

been subsiding, so that the true height of the tsunami looks as if it was nearer 400m. That's a quarter as high again as London's Shard – Western Europe's tallest building.

It's difficult to grasp the impact such an event happening today would have on our world's crowded coastlines. But with major collapses of ocean island volcanoes taking place somewhere on the planet as often as every 10,000 years or so, it may not be too long before we find out.

One prime candidate for the next big collapse is the Cumbre Vieja volcano on the Canary Island of La Palma, which has been behaving in a rather disturbing manner since an eruption in 1949. Then, the eruption was accompanied by some particularly strong earthquakes beneath the volcano's western flank, together with the opening of a 3km-long line of fractures along the crest of the volcano, down which part of the west flank dropped seawards by a few metres. This might have been no big deal but for the results of a survey of the volcano, undertaken by my research team between 1994 and 1997. It hinted that the west flank of the Cumbre Vieja might still be on the move, albeit extremely slowly.

More than a decade on and we are convinced that something a bit special is going on. Comparisons between GPS readings undertaken in 1997 and 2007, designed to monitor relative displacements, reveal some astonishing results. Not only is the entire west flank of the volcano deforming independently of the rest of the edifice, but over the intervening decade it moved westwards and upwards by more than 10cm. This may not sound like much, but it means that Cumbre Vieja's west flank qualifies as the most recently activated giant landslide, albeit moving at an incredibly slow speed... for now.

ATLANTIC ALARM

While the current rate of seaward movement is tiny, all the evidence points to the likelihood that at some time in the future, the west flank of Cumbre Vieja will fail, plunging into the North Atlantic. No-one has ever observed the formation of a megatsunami as a consequence of such an event, but we can build a realistic picture of what it might look like.

For a terrifying worst case, which envisages 500km³ of rock sliding into the sea at 100m/s, a computer model built by Steve Ward at the University of California, Santa Cruz predicts an initial bulge of water close to a kilometre high, subsiding into waves merely



Geologist Dave Tappin examines fossilised shells on Hawaii; evidence that a tsunami struck 120,000 years ago

“In the future, the west flank of Cumbre Vieja will fail, plunging into the North Atlantic”



On 11 March 2011 Japan was hit by a huge tsunami triggered by a magnitude 8.9 earthquake, resulting in a death toll of over 15,000

THE ULTIMATE WAVE MACHINE

A massive landslide in the Canary Islands is set to cause a devastating tsunami

BELOW IS A worst-case collapse scenario based on the rapid entry of 500km³ of rock into the North Atlantic from the Cumbre Vieja volcano. It predicts an initial bulge of water close to 1km high. As the bulge subsides, waves race outwards that, within 10 minutes, inundate the shores of La Palma and neighbouring islands to a height of several

hundred metres. An hour after collapse, waves 60–100m high crash onto the West African coast.

As the tsunami spreads outwards like a series of giant ripples, it encounters the UK after about six hours, with wave heights of 10–20m. To the west, a huge 'train' of widely dispersed waves heads for North America. Arriving first in Newfoundland, it works its way

down to low-lying Florida, which faces the prospect of waves 20m high or more.

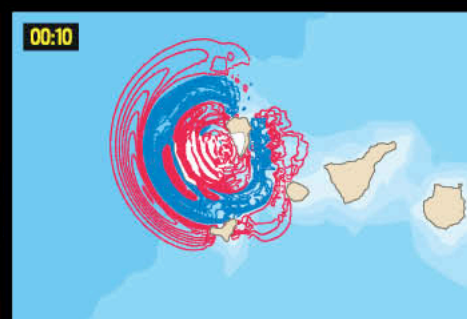
For a smaller collapse of rock of, say, 150km³, predicted wave heights are scaled down, but would still be extremely destructive. Along the coast of North America, for example, they would perhaps be 3–8m high rather than up to 20m.



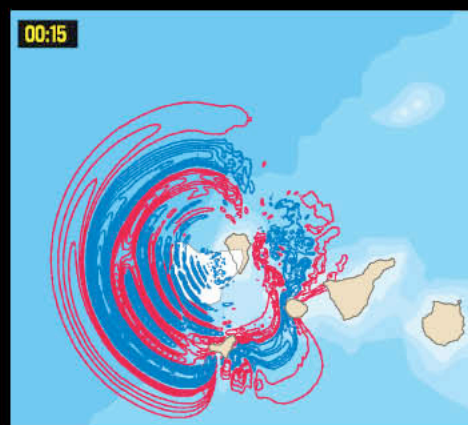
Two minutes after the collapse of the Cumbre Vieja a huge tsunami forms, with a wave cresting at nearly 1km high



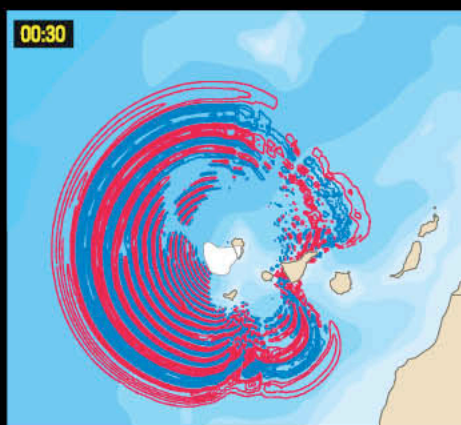
Five minutes after collapse, the trough of the wave reaches a staggering 1.3km below sea level



As it spreads out into the Atlantic the crest of the wave is still hundreds of metres high



A quarter of an hour after the landslide, the front of the tsunami is nearly 100m high, while the trough is close to 300m below sea level



Half an hour after collapse, and the tsunami forms a devastating ring of waves around the Canary Islands



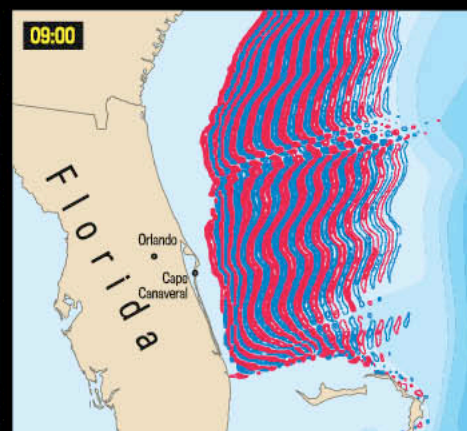
Just one hour after the collapse of Cumbre Vieja and 50–100m waves crash into mainland Africa along the coast of Western Sahara



The tsunami spreads out across the Atlantic with peak wave heights of 60m, with Spain and the UK hammered by 7m waves



Six hours after the landslide, Newfoundland is hit by 10m waves before larger 15–20m waves strike the north shores of South America



Florida then takes the brunt of the tsunami, with wave after wave hitting the coast, some reaching 20–25m in height



The destructive power of tidal waves laid waste to the city of Banda Aceh, Indonesia, in December 2004



A US Navy airman surveys the devastation in the Indonesian city of Meulaboh after a tsunami hit in 2004

➔ hundreds of metres high. This may sound like something from a science fiction film, but tsunami deposits identified more than 180m above sea level on the neighbouring island of Gran Canaria show that something similar has happened before. A wave of this size would have been unleashed after one of at least 14 collapses of volcanic flanks that occurred in the archipelago during prehistoric times.

Of course, it's perfectly possible that the future collapse, when it comes, will be smaller than the worst case, as a consequence of which the resulting tsunami will be reduced in height.

Certainly, marine geologist Dr Russell Wynn and colleagues at the UK's National Oceanographic Centre in Southampton have provided evidence for at least one ancient collapse in the Canaries occurring in a piecemeal manner. If the Cumbre Vieja were to fail in the same way, with the rock making up the flank sliding into the sea bit by bit over a period of hours, then although there would be more tsunamis, each would be smaller and less destructive.

However, everything we know about past volcano collapses points to the fact that when a volcano sheds a part of its flank, it usually does so very quickly, with most of the material sliding off in one go. While we can't be certain, the weight of evidence suggests that when the west flank of the Cumbre Vieja eventually plunges into the North Atlantic, the resulting tsunami will be prodigious and unprecedented in the historical record.

UK: DISASTER ZONE

This news is not good for the Canary Islands, but what about further afield? One of the controversies about tsunamis is just how well they conserve their energy as they travel further and further from the source, and how high they will be when they reach distant shorelines.

“The waves will remain big enough to cause major destruction as far away as the UK”

The original tsunami model for a future collapse of the Cumbre Vieja, published in 2001 by the aforementioned Steve Ward and University College London's Dr Simon Day, supports the idea that sufficient energy is conserved as the tsunami spreads out across the North Atlantic so that the waves remain big enough to cause major destruction as far away as the UK, West Africa and even the east coast of North America. Other experts disagree, suggesting that a future megatsunami would lose energy more rapidly as it travelled, resulting in waves along the east coast of North America that were just a few metres high.

Ward and Day, however, stick to their guns. As Steve Ward observes: “The 2011 Japan tsunami struck a few hundred kilometres of coast. Imagine the same level

of damage spanning shores 10,000km long – from Nova Scotia to Brazil, from Casablanca to Keflavik.”

Ward and Day do have some independent support for their predictions. Far out in the middle of the Atlantic, the island of Bermuda sits bang in the path of any tsunami heading west. In addition to its eponymous shorts, the island is also known – among geologists, at least – for some enigmatic deposits exposed along its coastline. These take the form of shell and coral debris resting 20m above sea level. Gary McMurtry of the University of Hawaii and Dave Tappin of the British Geological Survey are of the opinion that this material was dumped by a passing tsunami hundreds of thousands of years ago.

The obvious source is an ancient collapse of one of the Canary Island volcanoes. Should this prove to be the case, then it will go a long way towards supporting the idea that a future collapse of the Cumbre Vieja could present a serious threat to the entire Atlantic Basin.

THE WAITING GAME

But when is this all going to happen? Unfortunately, we don't know. The average frequency of flank collapses in the Canary Islands is about every 100,000 years, but given that the Cumbre Vieja's west flank is already on the move, it is likely to meet its watery grave much sooner. We might well have to wait thousands of years, but the collapse could happen at any time. As Dr Simon Day points out, this is most likely to happen during an eruption, “when the volcano is subjected to the additional forces imposed upon it”.

In theory, there should be warning signs in the form of an acceleration in the rate of sliding. Provided the volcano is being monitored, this should allow an alert to be raised, ensuring the evacuation of threatened coastlines. In the meantime, don't be dissuaded from visiting the beautiful island of La Palma. Soak up the Sun and visit the volcano. You'd be very unlucky to get caught up in a megatsunami-forming landslide. ■

BILL MCGUIRE is Professor of Geophysical & Climate Hazards at University College London

Find out more



Watch *Megatsunami* on BBC Two this month, a drama about the destruction caused by a collapse of Cumbre Vieja. See radiotimes.com for details

MEGATSUNAMI WATCH

Around the world, huge landslides are set to wreak destruction on coastal settlements



Off the coast of Sumatra, an unstable undersea fault could cause disaster

SUMATRA

A segment of the Sunda Megathrust Fault off the coast of Sumatra (Indonesia), which has not ruptured since 1797, is fully primed and ready to go. When it does, it's predicted to trigger a massive earthquake – as high as magnitude 8.8 – as well as a 5-6m-high tsunami. The devastating waves will reach the Indonesian city of Padang – population close to 1 million – within 30 minutes. While some preparations are being made to counter the threat of this sleeping giant of a disaster, the chances are that the level of death and destruction will be very high.

CASCADIA SUBDUCTION ZONE

The Cascadia Fault extends northwards for more than 1,000km along the west coast of North America, from northern California to midway along Vancouver Island in Canada. In 1700 the fault ruptured, generating an earthquake of around magnitude 9, which triggered a massive tsunami that was destructive even as far as Japan. A major earthquake of a comparable size has a fair chance of happening within the next 50 years or so, leading to a potentially devastating tsunami striking the Pacific coastline of the United States and southern Canada.



The Californian coast sits on the Cascadia Fault, which could generate a devastating tsunami



THE PUERTO RICO TRENCH

The Puerto Rico Trench marks the join between the Caribbean Plate to the south and the North American Plate to the north. With a maximum depth of more than 8km, it forms the deepest part of the Atlantic Basin. Submarine imagery reveals numerous giant landslides in the trench that were triggered by ancient earthquakes. It is now more than 200 years since a major quake struck the region, and there is some concern that a future combination of a huge quake and a resulting landslide could trigger a tsunami that could be destructive across much of the Caribbean.

GREENLAND

Eight thousand years ago, an earthquake caused by melting of the Scandinavian Ice Sheet triggered the great Storegga landslide, off the coast of Norway, spawning a tsunami that inundated the Shetlands and the east coast of Scotland. As Greenland's 2-3km-thick ice cover melts at an increasingly rapid rate, the faults beneath, which have been locked under the weight of the ice for tens of millennia, will be able to move more easily. Resulting earthquakes could, in turn, trigger submarine landslides similar to Storegga, capable of sending tsunamis surging across the Atlantic.



Greenland's melting ice could release powerful tsunamis across the Atlantic

IN AWE OF AURORA

Instruments housed beneath glass domes on the Kjell Henriksen Observatory in Norway are providing intriguing insights into the mechanisms behind the spectacular Northern Lights

PHOTO: OLIVIER GRUNEWALD

RAE

As the Sun's activity reaches its peak this month, **Stuart Clark** looks at how science is closing in on the secrets of heavenly light displays

BOMBARDED FROM SPACE, the air glows; shimmering curtains of light drift across the sky to form aurorae. In centuries gone by, the Vikings believed they represented the beauty of dead maidens. Other cultures thought the greens and reds were gods either at play or war.

Despite having been transfixed by aurorae for centuries, there are some surprising gaps in our knowledge about how they develop and exactly what's going on inside them. But this year will be an important one for aurora researchers, because the chances of seeing these celestial firework displays are the best they have been for a decade.

An aurora is the result of electrically charged particles thrown off by the Sun. If those particles happen to get caught in the Earth's natural cloak of magnetism,

they can be funnelled down into the atmosphere, where they collide with oxygen atoms and set them glowing (see 'How it works: the aurora', on p77). And this May, the Sun is expected to reach the peak of its 11-year activity cycle. Although this 'solar maximum' is unlikely to be a particularly eventful one, there will still be more solar flares than at other times, releasing more charged particles.

It means this year is likely to be a busy one for researchers at the Kjell Henriksen Observatory in Norway – the largest observatory of its kind dedicated to studying aurorae. Run by the University Centre in Svalbard, an institution that specialises in Arctic studies, it is located on a group of islands between mainland Norway and the North Pole. Its northerly location means the six scientists who work there endure some pretty inclement weather – the average



➔ summer temperature is little more than 4°C. But it's also one of the few places on Earth where you can see aurorae during the day – for a 10-week period around the winter solstice it is sufficiently dark.

Beneath domes on the observatory's roof sit an array of optical instruments – cameras, photometers, which measure the intensity of light, and spectrometers, which split light into different wavelengths and measure their intensity. A key instrument at the observatory is a 32m-diameter radar. It emits radio waves into the atmosphere that are reflected back. The returned signal enables researchers to study particles in the upper atmosphere – electrons and ions – creating the aurorae. “Combining the measurements from the optical instruments and the radar we can learn more about what's going on inside aurorae through the different layers of the atmosphere,” says Dr Margit Dyrland, one of the scientists at the observatory.

Among the more recent additions to the observatory's equipment is NORUSCA II – the ultimate aurora camera. Whereas your average camera is effectively a ‘light bucket’, bringing together all the wavelengths of visible light into one image, NORUSCA II is a ‘hyperspectral’ camera that can simultaneously capture 41 wavelengths so each can be analysed separately. “It can detect specific atmospheric constituents by their unique fingerprint – the wavelengths of light they emit,” says Prof Fred Sigernes, who runs the observatory. These spectral signatures can reveal subtle changes in atmospheric behaviour, such as the ionisation of gases, during aurorae.



In some parts of the world aurorae can even be seen during the day, such as this display from Jökulsárlón lake in Iceland

“We want to find out how aurorae disturb GPS signals and high frequency communications”

Dr Margit Dyrland, atmospheric physicist at the University Centre in Svalbard

Even during the camera's first stint of research, back in January 2012, it proved its worth. It revealed something unexpected – a faint wave pattern in the lower atmosphere that resembles airglow, a weak emission of light by Earth's atmosphere. It's produced by several sources, including cosmic rays striking the upper atmosphere. And its appearance at the same time as an aurora suggests it may also be caused by a previously unrecognised source.

RECORD BREAKER

The largest aurora we know of hit our planet on 2 September 1859. Two-thirds of the atmosphere was bathed in celestial glows after a giant solar flare triggered a massive eruption of gases. The appearance of this gigantic aurora coincided with the widespread disruption of magnetic and electrical systems. In the 19th Century, these mainly took the form of compass needles, which spun uselessly, and the telegraph. The long cables needed to relay messages were perfect conduits for the aurora.

The buffeting of the Earth's magnetic field by the solar particles, known as space weather, induced electrical currents far larger than normal in the wires. These not only swamped messages but caused sparks to leap from the equipment, in some cases stunning operators unconscious and setting offices aflame.

Today, we are almost totally reliant on electrical technology. Satellites and power grids are vulnerable to space weather and this is an area where the observatory at Svalbard could help. “As well as learning about the particles through different layers of the atmosphere, we want to understand how aurorae disturb GPS signals, high frequency communications and the like,” says Dyrland.

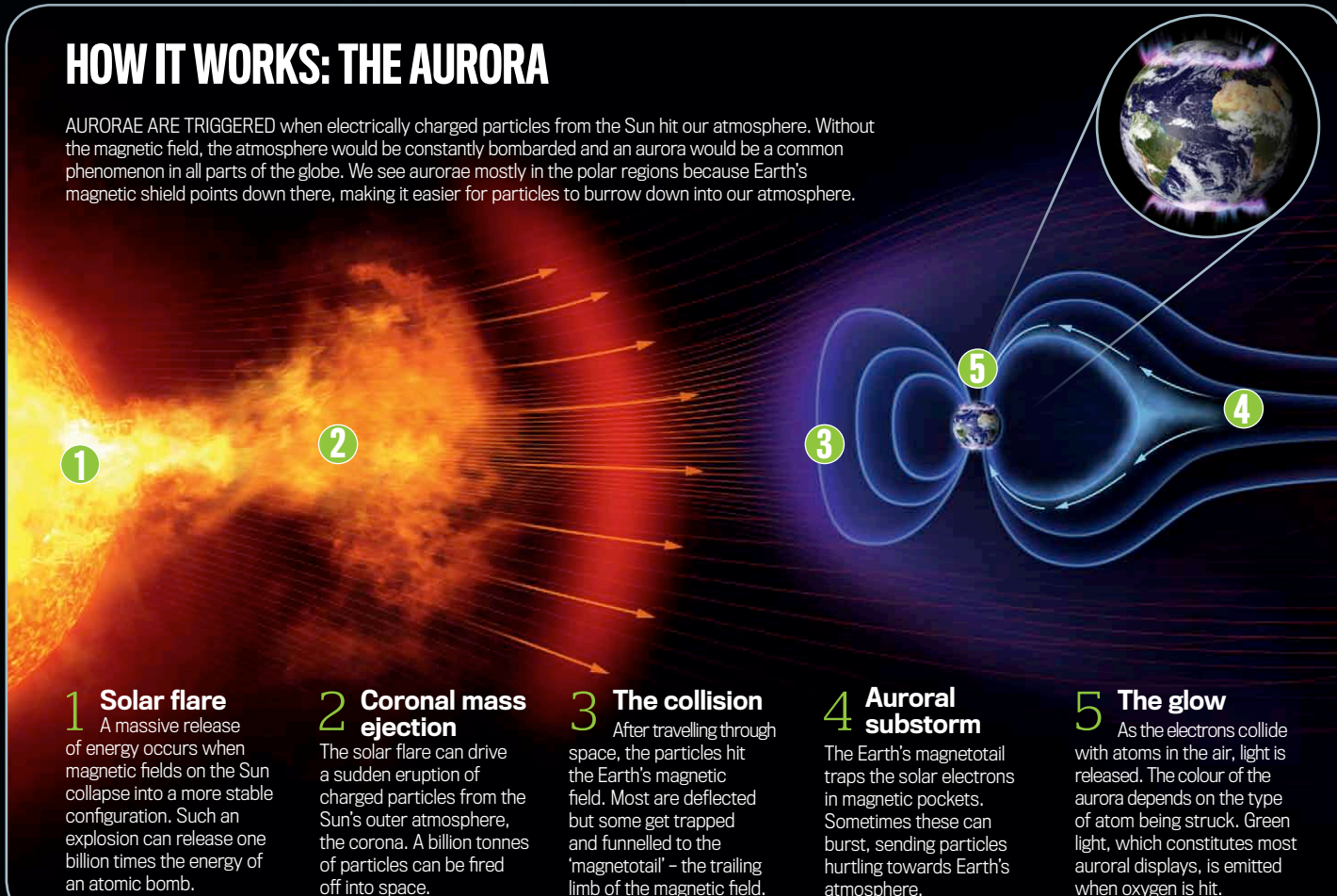


A scientist stands on the 32m-diameter radar at the Kjell Henriksen Observatory as it probes particles in an aurora

The green curtains of the Northern Lights are formed when charged particles from the Sun strike oxygen atoms in the upper atmosphere

HOW IT WORKS: THE AURORA

AURORAE ARE TRIGGERED when electrically charged particles from the Sun hit our atmosphere. Without the magnetic field, the atmosphere would be constantly bombarded and an aurora would be a common phenomenon in all parts of the globe. We see aurorae mostly in the polar regions because Earth's magnetic shield points down there, making it easier for particles to burrow down into our atmosphere.



HOW TO SPOT AURORAE IN THE UK

Handy hints for seeing this natural light show

THE UK IS not in the best position to see the aurorae. Countries near the Arctic Circle are much better placed – that's why the Kjell Henriksen Observatory is where it is. Not all is lost, however. This May the Sun is expected to reach the height of its cycle of activity. Known as solar maximum, researchers bank on there being more solar flares, and therefore more 'space weather', which can trigger the aurorae.

"Solar maximum is definitely the best time to be looking for aurorae from the UK," says Dr Gabby Provan of the University of Leicester. The solar flares during solar maximum can be large and

energetic. This makes the aurora creep down from the polar latitudes as Earth's magnetic field comes under increasingly strong bombardment.

To see an aurora, you need a clear northern horizon because this is the direction from which a display will appear. The University of Lancaster maintains a website called AuroraWatch UK – <http://aurorawatch.lancs.ac.uk/>. It uses a simple colour-coded system of warnings. Green: forget it and stay in the warm.

Yellow: aurorae are possible but only in the extreme north of Scotland. Amber: aurorae are likely in Scotland, northern England and Northern Ireland. Red: aurorae are likely in all parts of the UK.

A spectacular display pictured near Aberdeen, Scotland



"We also want to be able to provide warnings about solar storms that might harm vital infrastructure on Earth."

THE AURORA MACHINE

But aurora researchers aren't just peering into the skies, they're creating their own. At the University of Leicester is the Planeterra – an aurora simulator. It features a miniature Earth made out of metal with a magnet inside to simulate our planet's magnetic field, as well as an electron gun that acts as the Sun, firing particles at the metallic world. The whole thing sits in a vacuum chamber and when the gun is switched on, a beautiful glow – an aurora – appears around the miniature Earth. "It's pretty authentic," says Dr Gabby Provan of Leicester University. "To get an auroral glow you have to leave one-ten thousandths of atmospheric pressure in the chamber, since air is much thinner at altitudes where aurorae are observed."

Although mainly a teaching aid, the Planeterra is used for research. "I can simulate the magnetic fields of other planets," says Provan. Uranus, for example, is unique in the Solar System as there is a significant misalignment



When radio waves return to the Kjell Henriksen Observatory's 32m radar dish, scientists gather information about particles in the upper atmosphere that give rise to celestial light displays

between its magnetic poles and its rotation axis. Whereas Earth's magnetic north is just 11° away from the North Pole, on Uranus the angle is almost 60° ; follow a compass on Uranus and you would end up close to the planet's equator rather than its pole. It also means aurorae appear at equatorial latitudes more often than the polar regions, something that can be simulated by moving the magnets inside the Planeterrella.

"I often see professors standing around the Planeterrella discussing what is happening to the electrons in there," says Provan, who studies aurorae on other planets. Jupiter is a favourite. Its magnetic field is so strong it forms an almost impenetrable barrier to the Sun's particles. You may think that this makes the planet aurora-less – but not so. Its volcanic moon, Io, spews charged gas, some of which is guided by the magnetic field to the poles of Jupiter, where it sparks aurorae.

A SMOKING GUN

But there are still some fundamental questions to be answered about aurorae here on Earth. "You'd imagine that we would know it all by now," says Dr Jim Wild, an aurora researcher at Lancaster University. "But we're not entirely sure of the mechanism behind the gun."

The gun in question is the magnetic field close to Earth. Somehow, at altitudes of about 5,000-10,000km, it configures itself into a natural particle accelerator that fires particles into the atmosphere, producing the aurorae. The European Space Agency's Cluster mission has been in space investigating this effect. It maps the ever-changing magnetic landscape and, on 5 June 2009, it passed through one of these natural particle accelerators for the first time. The data revealed that the correct configuration is only stable for about five minutes. So auroral displays that last for hours must be powered by many of these forming spontaneously out of the ever-shifting magnetic landscape. But to test this more data is needed and Cluster cannot always be in the right place at the right time.

We need to keep our gaze fixed on aurorae using facilities like the Svalbard observatory as well as eyes in space. "We're just beginning to understand how closely our planet is connected to space," says Wild. Aurorae are a clear demonstration of that link, so understanding more about them will be vital in coming years. ■

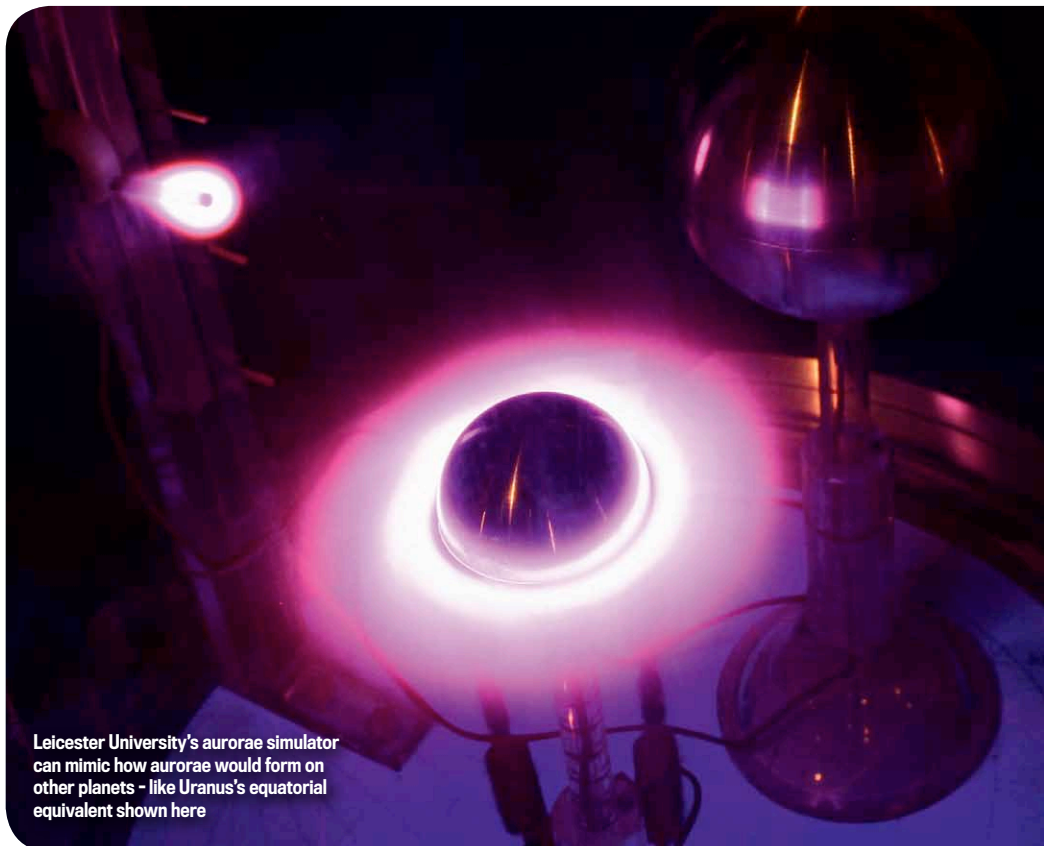
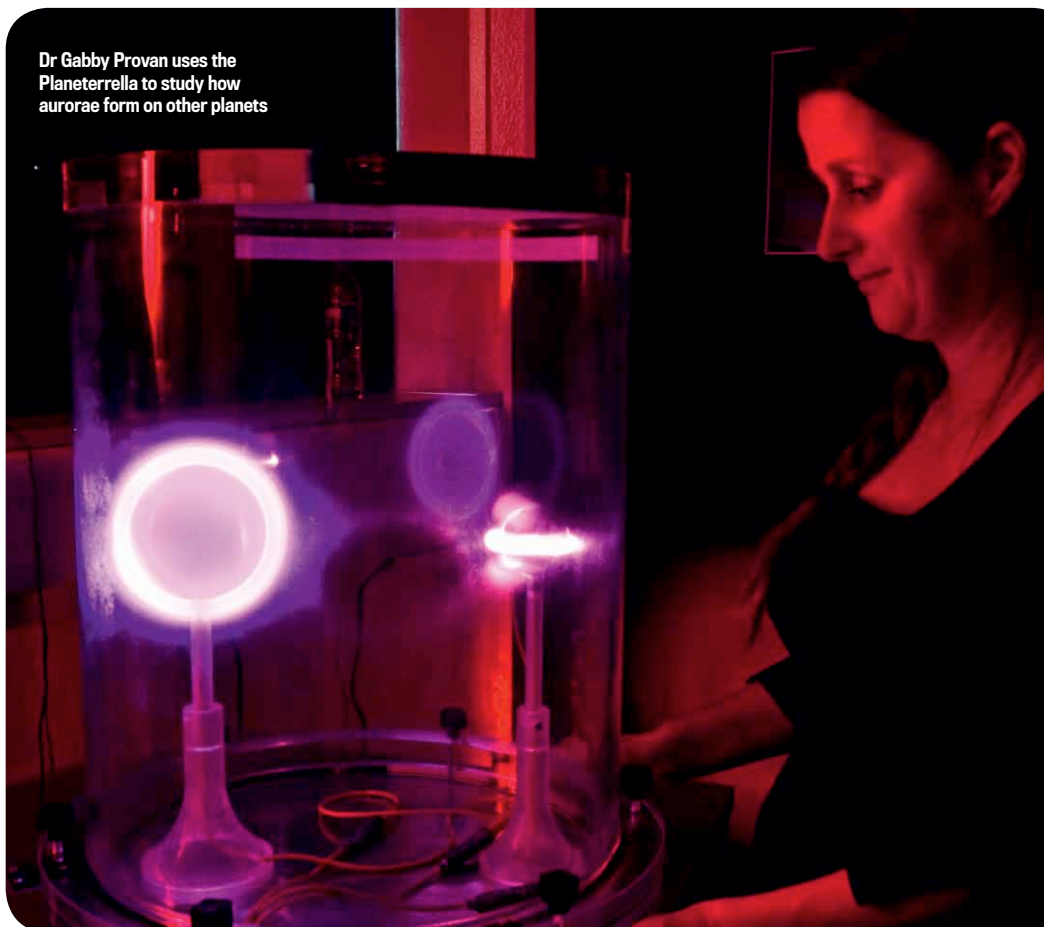
DR STUART CLARK is an astronomy journalist and the author of *Voyager*

Find out more



Watch an episode of *The Sky at Night*, in which the team go in search of the Northern Lights. <http://bbc.in/xr8yGQ>

Dr Gabby Provan uses the Planeterrella to study how aurorae form on other planets



Leicester University's aurorae simulator can mimic how aurorae would form on other planets – like Uranus's equatorial equivalent shown here

SAIL NORWAY'S ICONIC COASTLINE THIS WINTER IN SEARCH OF THE NORTHERN LIGHTS

Photo: Laurent Patin



This winter, go in search of the incredible Northern Lights on an authentic Hurtigruten coastal voyage. There really is no better time or place to witness this breathtaking phenomenon. NASA have forecast the best 'lights' in a decade due to the solar maximum, and our ships sail the iconic coast of Norway, far from the effects of urban light pollution and directly beneath the Aurora Oval (the epicentre of Northern Lights activity). On board our ships you'll enjoy fantastic local cuisine, comfortable cabins and the company of like-minded passengers. We also offer a choice of exciting and interesting excursions including dog sledding, snowmobiling through the polar night and the rugged North Cape.

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THE FUTURE OF GADGETS

TECHHUB

THIS MONTH

BILL THOMPSON
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EDITED BY **DANIEL BENNETT**



RAZER EDGE
RAZERZONE.COM,
\$1,000 (£665)

The Razer Edge transforms into a handheld games console with a dinner tray-like attachment

ON THE HORIZON

RAZER EDGE

At a time when every tablet manufacturer and its dog is purporting to offer The Next Big Thing, the Razer Edge may just be the genuine article. On the surface it looks like yet another shiny

Windows 8 touchscreen computer, but beneath its screen lies enough computing power for this to be the one singular computing device you'll ever need.

On its own it's as sleek and light as any other 10-inch tablet, but attach the bespoke keyboard, and it turns into a laptop – nothing new there, you might think. Slot it into a docking station and now you've got a home games console, powerful enough to play the latest PC games, that'll stream games and movies to your TV.

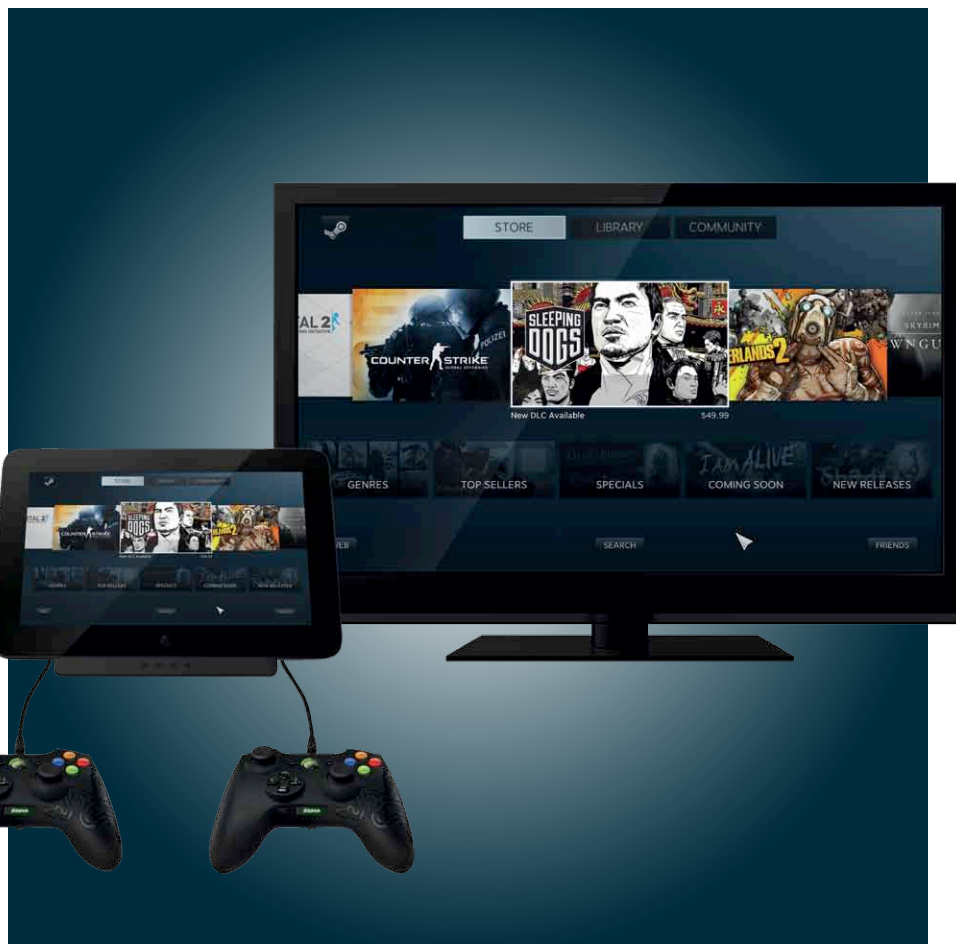
Most intriguingly of all, the Edge also supports a custom frame that transforms it into a handheld games machine so you can take your high-end PC titles with you. Though the final result is weirdly suggestive of a TV dinner tray.

Aesthetic quirks aside, the Razer Edge is a remarkably versatile device. Transforming tablets are hardly a new concept, but this is the first we've tested that credibly performed so many different roles so well. It's a similar weight and size to the iPad,

PC games ran smoothly, and when paired with a gamepad it felt just like playing on an Xbox 360.

Peek under the hood and you'll find a commendably powerful set of components: depending on the configuration you plump for, there's an Intel i5 or i7 processor, a top of the line graphics card, and an ultra-fast solid state hard drive. In real terms, this offers enough juice to run games like *Skyrim* without a hitch. The Edge should also be able to handle intensive





Having finished reading the news on the train with the Razer Edge, you can come home, stick it in a dock and play PC games and movies on your HD TV - then it will even do the washing up... well, maybe one day



games like *Battlefield 3*, but not at the maximum level of graphical detail.

All in all it's an exciting prospect, but there are a few hurdles to consider before you bludgeon your piggy bank. For starters, its launch price in the US demonstrates that the machine won't be cheap. The low-end version of the tablet will set you back a hefty \$1,000 (£665), and that model is arguably stymied by a measly 64GB hard drive; if you actually plan to play games, that space will disappear quickly. For a more practical 128GB or 256GB model you'll need to cough up an extra \$300 (£200) or \$450 (£300) respectively. Those fancy peripherals don't come free, either: the docking station costs \$99 (£65), while the 'dinner tray' clocks in at \$250 (£165).

Such vertiginous prices are likely to deter all but the most deep-pocketed of consumers. This potentially limited market could put off other tablet manufacturers from following the company's example - meaning that we might never end up with 'one device to

rule them all'. That's the view of Adam Leach, principal analyst at IT and telecoms research firm Ovum. "I think the problem with this for the bigger manufacturers is that it's a niche market," he says. "There's a lot of R&D effort required and these are high-end machines, but it's a small segment of the market that will be willing to pay this much."

But in the case of the Razer Edge, Leach believes that the "high-quality for high-cost" gambit could still pay off. "This could really appease people who enjoy high-end gaming," he says. "They're not necessarily going to spend a premium on a desktop PC and then more on something portable. This is trying to be the best of both worlds, and I think that's sensible."

When the Razer arrives in the UK later this year it will be the most powerful tablet on sale, but whether it will pry people from their iPads remains to be seen.

NEON KELLY is deputy editor at videogamer.com

TECHOMETER



WHAT'S HOT

THE CRASH-PROOF COMPUTER

Scientists at University College London claim to have built the world's first crash-proof computer. Their 'systemic' PC abandons the linear methods of traditional computing in favour of tasks that are 'distributed, decentralised and probabilistic', mimicking systems from the natural world. By duplicating processing and data in multiple locations, the computer is said to become immune to fatal digital snarl-ups.

WHAT'S NOT

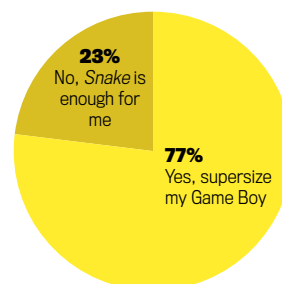
HOTMAIL

Good old Hotmail... for all its flaws, we can remember the days when, if you wanted email access away from your home or office PC, it was pretty much the only option. But now it's finally set to go into the Recycle Bin of internet history, as Microsoft rolls out its replacement: Outlook.com. Current Hotmail users - all 360 million of them - should all be 'ported over' by the end of summer.



READER POLL

Do you want to play PC quality games on the go?





EARLY ADOPTER BILL THOMPSON

Help me, Obi-Wan Kenobi

Ever since I saw a holographic Princess Leia ask Obi-Wan for help, I've been waiting for the day I could send a holographic message of my own. Sadly, 35 years after first watching *Star Wars*, we're still waiting for a virtual David Attenborough to pop up in our living rooms.

The closest tech we can buy is a 3D TV. But the current crop of 3D tellies only provide a limited amount of depth, and for the most part rely on cumbersome glasses that no one seems to want to wear. As a result 3D-TVs have failed to wow and sales have been meagre.

At this year's Consumer Electronics Show – where the world's tech companies launch their latest tech – there were, hidden away in the conference's less travelled hallways, lines of what appeared to be holographic displays. There was little fanfare surrounding them since they were tucked away in an out of the way quarter of one of the halls. Some beamed out 3D adverts in mocked up shop windows where holographic celebrities marvelled at new running shoes, while others recreated live music performances at one-eighth of the scale. The best examples relied on advanced stereoscopic

display technology – like that used by the Nintendo 3DS – to create a dramatic sense of 3D. Others created the illusion using mirrors, but none were convincing.

All the demos were grainy, and the small 3D people didn't quite feel solid. It seems for the moment that the technology needed to create a convincing holographic display is some way off. So how



will we interact with our technology in the future? Will we stick with flat 2D panels or will something else take its place?

One exciting possibility is a piece of hardware that's already here. It's called zSpace and it creates 3D images that you can interact with. It uses a passive 3D system, like you get at the cinema, but with the added ability to track the position of the viewer's head. By following a series of dots painted on the polarised specs that you have to wear,

it is then able to create 3D images that are precisely tailored to your viewing angle. In this way it can create a virtual object that appears to float above the screen, which it does at 60 frames per second. What's more is that it comes with a stylus, also tracked by the camera, so you can 'touch' the virtual object.

In the end, though, the solution might not involve building displays that create the illusion of solid objects. Instead it might be an extension of the virtual and augmented reality techniques seen in products like Google's Project Glass.

It might be even better than glasses. Before founding Project Glass, Babak Parvis was working on creating virtual reality contact lenses that draw images directly on your retina with low-power lasers. If you can do that, and do it well, then you don't need to go to all of the effort of creating 'solid' objects in space – you can simply give everyone the same visual input they would have got had they been looking at the 'real' thing. And that would be better than any hologram, princess or no princess.

Bill Thompson contributes to news.bbc.co.uk and the BBC World Service

COMING SOON

3 MONTHS

WIKIPAD

Wikipad is a 7-inch Android tablet that can be used on its own, or popped inside the accompanying controller for mobile gaming. As well as over 100,000 Android games, it is certified for PlayStation Mobile, giving you the likes of *Sonic 4* and *Assassin's Creed*. Wikipad.com



+ **Nvidia Project Shield** This looks like a traditional handheld games console, but it will pack PC-quality graphics. Nvidia.com

+ **Android Key Lime Pie** Details of Google's latest mobile operating system may have been announced by the time you read this, but the first smartphones are likely to take a little longer to arrive.

6 MONTHS

LENOVO IDEACENTRE HORIZON

Is a 27-inch tablet running Windows 8 the stupidest, most cumbersome idea ever, or does it mark the starting point of a future of touch-screen coffee table gaming that you've always been dreaming of? Lenovo.com



+ **Intel TV** Intel has confirmed it's working on a TV service, consisting of 'live TV, catch-up TV and on-demand, plus a range of apps'. Intel TV will be available on mobile devices, as well as a set-top box. Intel.com

+ **Xbox 720** There's still no official word from Microsoft. All the same, expect it to be in stores by Xmas. Xbox.com

9 MONTHS

APPLE SMARTWATCH

There's no official confirmation from Apple that this is ever going to happen, but at time of writing, the latest rumours suggest there's already a team of 100 developers working on it. Whether it will replace your iPhone or merely work in tandem with it (like the Pebble watch) remains to be seen. apple.com



+ **LG EA9800** OLED technology means that TVs can now be curved! While we all figure out if that's a good thing or not, LG and Samsung will be putting rounded screens into production for next year. LG.com

+ **Samsung Youm** Samsung is also using OLED display tech to create a flexible phone, meaning the screen will be near unbreakable. Samsung.com



TELL US WHAT YOU THINK!

Are you looking forward to holographic TV? Tell us what you think by emailing us at reply@sciencefocus.com



JUST LANDED

SPLIT PERSONALITY

Can't decide whether to buy a tablet or a laptop? The Taichi is both. **Russell Deeks** flips its lid

TAICHI 21, £1,499
ASUS.CO.UK

What is it?

The Taichi 21 is Asus's latest 'hybrid' – a device combining the practicality of an ultrabook with the convenience of a tablet. There are, of course, many such hybrids available – Lenovo's IdeaPad Yoga and Helix, Microsoft's Surface, HP's Envy x2 and Asus's own Transformer Pad, to name a few. But the Taichi 21 is different – rather than being essentially a tablet with added keyboard, it's a fully-functioning Windows 8 ultrabook that happens to have a tablet in the lid.

The Taichi 21 can operate in several different modes: you can use it purely as an ultrabook when it's open, solely as a tablet when it's shut, or have the second (exterior) screen either mirror the ultrabook desktop, or function as a second display. No complicated configuration process is required to do this: you simply hit a dedicated blue button on the keyboard

to toggle through the various display modes, or close the lid to go into tablet mode. It's simple enough for your grandmother or your six-year-old to grasp in seconds.

Is it powerful?

Given the hefty asking price, you'd expect the Taichi's specs to be respectable – and they are, with 4GB of RAM, twin 11.6-inch 1920x1080 HD displays, Bang & Olufsen audio hardware and 128GB or 256GB SSD drive. There's a decent array of ports including 2x USB, audio-in/out, VGA and micro HDMI, and it weighs just 1.25kg – just 170g more than an 11-inch MacBook Air, despite the second screen.

As with most Windows 8 devices you can toggle between

the button-based interface or a more traditional Windows desktop at will – and this is where the dual nature of the Taichi 21 really comes into its own. Because let's face it: some things are easier to do using a touchscreen interface, while some things are best achieved using a trackpad or mouse. If you're merrily browsing away, for instance, a tablet's great – but if you need to enter a long URL directly, typing it in on a fiddly on-screen keyboard is a pain. With the Taichi 21 you just flip the lid open, type in the URL on a decent-sized proper keyboard, then close the lid to carry on swipe-surfing at leisure. And that's before we even start to talk about doing anything actually useful, like typing a document or editing a spreadsheet.

Should I buy one?

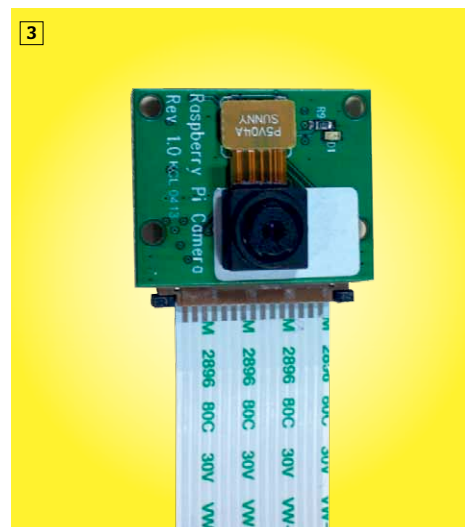
At this price, you'll want to think carefully about what you'll use the Taichi 21 for. If you just want a tablet for surfing, watching movies or playing *Angry Birds*, but want a keyboard for bashing out the odd email, there are many hybrid/dock solutions that'll do the job just as well for less.

For this reason, a lot of early blog reviews of the Taichi 21 have slated it (pun intended). We've heard the secondary display option described as 'utterly pointless' (by people who've presumably never needed to give a presentation or sales pitch, or run a training session). And we've heard grumbles that the interior screen isn't touch-based (how terribly 20th Century, darling).

But such reviews miss the point of the Taichi 21 entirely. If you want a proper full-spec ultrabook, but with the added convenience of a tablet when required, it's ideal.

RUSSELL DEEKS is a freelance technology journalist


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APPLIANCES OF SCIENCE

1 EMERGENCY CALLS ONLY

Ideal for outdoor types, or for making sure Granny or the little 'un can always reach you in an emergency, the screen-free SpareOne phone can run off one AA battery for 15 years (yes, *years*) and doesn't require a SIM. It features a big red button for emergency calls and a built-in torch, can store up to nine numbers and is available for all major GSM networks, both in the UK and overseas. **SpareOne phone** www.spareonephone.com, £59.99

2 A LITTLE BIT CLEVER

After knocking around as a concept for a few years, you can now buy these electronic building blocks. Best thought of as being like LEGO or Meccano for budding electronics engineers, littleBits come in kits of 3, 7, 10 or 14 colour-coded pieces – including buzzers, LCDs, heat sensors and more. These snap together magnetically to form electrical circuits. What you build with them is up to you. **littleBits** littlebits.cc, \$29-\$149 plus P&P

3 PI IS FOR PICTURES

Wondering what to do next with the Raspberry Pi, your diminutive DIY computing marvel? How about turning it into a webcam, or making it the brains of a remote reconnaissance robot? With this new correspondingly tiny camera add-on, such applications are now perfectly feasible. It's got a 5-megapixel sensor and can capture 30fps video at resolutions up to 1080p. **Raspberry Pi camera module** raspberrypi.org; \$25 plus P&P

4 PUCK 'ER UP

Currently seeking funding on Kickstarter, Puck uses heat from your cuppa to juice up your iPhone or other USB-charged device. It's based around a Stirling engine – a 19th Century rival to steam – that generates electricity from temperature differences: put a mug of tea on the red side or a chilled drink on the blue side and you can then plug your phone in to give it some juice. **Epiphany One Puck** epiphanylaboratories.com; price TBC

5 GOING SOLO

A lot of us are filming more of our daily lives than ever. But filming *yourself*, if you're moving about, can be tricky. Enter the Soloshot mount, which can be used with any camera with a tripod fitting. Set it up and the mount automatically tracks a wireless transmitter worn as an armband – whether you're filming your skateboarding stunts or just posting clips of yourself chasing the dog on YouTube. **Soloshot** Soloshot.com, \$479

6 THUMB DRIVE

One of the biggest headaches of modern life is having to keep track of dozens of different passwords and log-ins. US start-up Arkami aims to change that, by letting you store them all on a USB drive that's biometrically protected. Swipe your thumbprint to activate the drive, then use voice-activated search to tell it which log-in you want to use. It'll work with smartphones and tablets via Bluetooth, too. **Arkami myIDkey** myidkey.com, £TBC

How I Improved My Memory In One Evening

The Amazing Experience of Robert Heap

"Of course I place you! You're Bob Humphries of Birmingham."

"If I remember correctly — and I *do* remember correctly — John Kershaw, the supermarket man, introduced me to you at the dinner of the Bowls Club three years ago in October."

The assurance of this speaker — in the crowded corridor of the Hotel Piccadilly— compelled me to look at him.

"He is Dr. Bruno Furst, the most famous memory expert in the world"

"He is Dr. Bruno Furst, the most famous memory expert in the world," said my friend Keith Clark. "He will show you a lot more wonderful things than that before the evening is over."

And he did.

As we went into the banquet room the toast-master was introducing a long line of guests to Dr. Furst. I got in line, and when it came my turn, Dr. Furst asked, "What are your initials Mr. Heap, your occupation and telephone number?" Why he asked this, I learned later, when he picked out from the crowd the sixty people he had met two hours before and called each by name without a mistake. What's more, he named each person's occupation and telephone number.

"I can teach you the secret of a good memory in one evening"

When I met Dr. Furst he rather bowled me over by saying: "There is

nothing miraculous about my remembering anything I want to remember, whether it be names, faces, figures, facts, or something I have read.

"You can do this as easily as I do. Anyone with an average mind can learn quickly to do exactly the same things."

"Dramatic Improvement"

"I used to be laughed at in the office here about my poor memory and I must admit with a lot of truth. Since I started your Course my memory has improved out of all recognition!"

Mr. J.W. Sullivan, London S.W.2.

"That is alright for you, Dr. Furst," I interrupted, "you have given years to it. But how about me?"

"Mr. Heap," he replied, "I can teach you the secret of a good memory in one evening. This is not a guess, because I have done it with thousands of pupils. In the first of twelve simple lessons which I have prepared for home study, I show you the basic principle of my

"Examination Success"

"Excellent examination results have been sound enough proof to carry on adopting your technique for the rest of our lives."

Mr. S.N. Caldwell, Huddersfield, Yorkshire.

whole system, and you will find it just like playing a fascinating game. I will prove it to you."

He didn't have to. His Course did; I got it the next day.



When I tackled the first lesson, I was surprised to find I had learned — in about one hour — how to remember a list of one hundred words so that I could call them off forward and back without a single mistake.

Dr Bruno Furst's Course is fantastic! I can rely on my memory now. I can recall the name of anyone I have met before — and I keep getting better. I can remember any figures I wish. Telephone numbers come to mind instantly. What's more my concentration has improved.

"Best Investment"

"It is the best investment I have ever made. Why is it so cheap? The Course, apart from being so instructive, is easy to read and entertaining."

Mr. P.R. Jordan, (Ship's Officer)

My advice to you is don't wait another minute. You could be astounded to learn what a wonderful memory you have got. Your dividends in both business and social advancement could be enormous.

ROBERT HEAP

FREE DETAILS

Full details of Dr. Furst's easy-to-follow method for developing a powerful memory are contained in a free information pack. To obtain your copy just use one of the contact methods shown on the coupon below or visit our website **www.youcanremember.com**.

FREE INFORMATION PACK AND BOOKLET AVAILABLE

For your copy visit our website at

www.youcanremember.com

or call us with your details FREE on

0800 298 7070 quoting Focus Magazine

Please send me your **FREE** Memory information pack and booklet.

Name

Address.....

.....Postcode.....

Memory and Concentration Studies

Freepost FOM33T, Stockport, Cheshire SK6 6YA.

Email: FOM33E@youcanremember.com

Please include your full name and postal address



ULTIMATE TEST

HARDER, BETTER, FASTER

Health and fitness in the 21st Century is no longer a shorts and trainers affair. Tech rules when it comes getting lean, mean and fighting fit. James Witts works up a sweat... ➔



PHOTO: STUDIO4PHOTO.CO.UK

WHERE ONCE pedometers ruled, there's now a plethora of apps and tech-heavy devices designed

to monitor and improve your health. Calories burned, heart rate, blood oxygen levels... gadgets now measure every physiological parameter you can think of with the goal of transforming you into the next Mo Farah.

Nike's FuelBand (which we tested in *Focus* issue 244) is the poster boy for this new era of self-assessment. But the latest generation of health monitors have a host of new tricks.

DATA AND REWARDS

The **Tinké** is a plug-in for your iOS device and, according to its Singaporean inventors, will lead you to a better life. After downloading the free app and slipping the Tinké into your iPhone for instance, you press a thumb over two optical sensors and apply pressure. Red light and infrared combine to calculate readings based on blood volume changes. This allows measurement of your heart rate, breathing rate and oxygen saturation levels, combining for a fitness score – in Tinké terminology, a VITA rating. Simple.

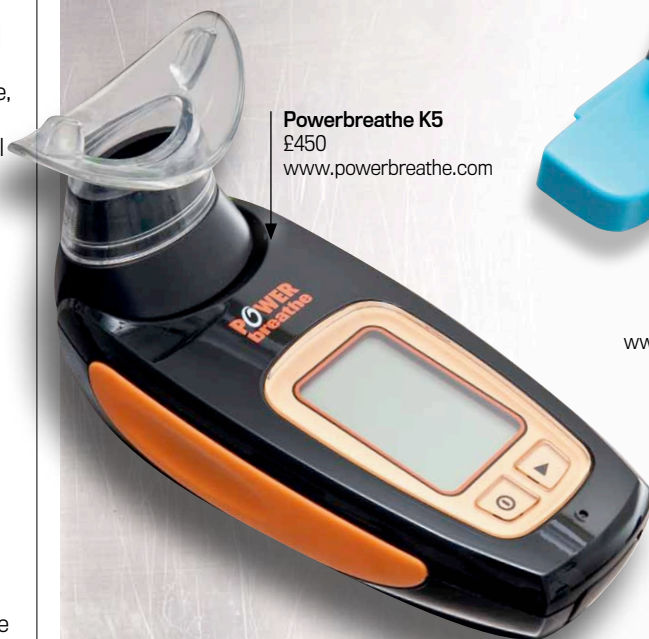
But is it of worth? No. Apart from receiving virtual badges, you've no idea what to do with the data. If you score under 50, for instance, should you drag yourself to the doctor's? The validity of its results is also questionable. At rest we measured a heart rate of 67bpm. A six-mile run later and, while using the Tinké during cool-down, it had risen to just 79bpm. A traditional two-finger carotid measurement came in at 150bpm. Overall, style over substance resonated loudly.

The **Fitbit One** was a far more credible product. Just clip it onto your belt or slip it into the included armband, and away you go. Via an accelerometer and altimeter within its black casing, it measures steps, calories burned, distance and stairs climbed.

Upload this data daily to your Fitbit account (PC and Mac), or to the Fitbit app (Android and

FIT FOR PURPOSE

We lived with these gadgets to find out whether they really will guide you to physical perfection



Powerbreathe K5
£450
www.powerbreathe.com



Tinké
£95
www.zensorium.com



Omegawave
£79.99, plus £7.90 per month after three months
www.omegawave.com



Fitbit Aria scales
£99.99
www.fitbit.com/uk



Fitbit One
£79.99
www.fitbit.com/uk

iOS), and chart your progress via graphs, tools and charts. It's jargon-free and usable – key to making this an integral part of a leaner you. Your account comprises a handy food log, too, which offers calorie counts for a long menu of foods. This lets you compare your calorific intake to what you've burned in a day.

There's a Facebook log-in option, highlighting its community appeal, and a global leaderboard refreshes throughout the day. Whether that convinces you to substitute fried chicken

for chickpeas lies with your competitive instinct.

It's not all about monitoring movement, though – wear it at night and it'll assess the quality of your sleep. And for even more self-analysis, including body fat measurement and body mass index, you could link your account to the Fitbit Aria scales (£99.99).

Sadly, Fitbit also suffered in the accuracy stakes. While it coped fine with general activity and walks, over several runs the distance measured had no bearing on the route we'd just

completed. If data is the key to health, it doesn't help if some of the data is inaccurate.

GOING PRO

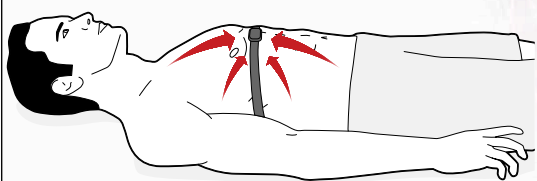
Used by five Champions League winners, the **Omegawave** certainly has credentials. It's been used at elite level for a few years but has just been launched to the masses, and is designed to 'measure your readiness' to train.

For £79.95 you receive an ECG sensor belt – like a heart rate monitor chest strap – and a three-month subscription to the app.

ARE YOU PRIMED FOR ACTION?

The Omegawave measures how prepared you are to exercise in four simple, but technologically advanced steps...

1 Run cold water over the Omegawave's strap and ECG sensor to increase the conductivity of the unit when you put it around your chest. Lie down for two minutes; breathing should be relaxed.



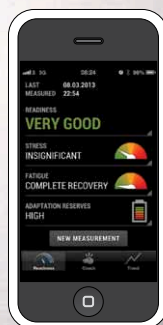
2 While you're lying down, the Omegawave's sensor measures electrical signals. This determines the variation in heartbeat-to-heartbeat intervals and the state of your nervous system.



3 Over two minutes, this data is sent by Bluetooth to the Omegawave app on your iOS or Android device. You're then given the current state of your cardiac system, fatigue levels and ability to cope with exercise that day.



4 Click on the 'Coach' option. With the self-assessment data from step three, here you're guided to the intensity you should train at. This ranges from strength conditioning to complete rest.



PERSONAL TRAINERS

Your smartphone can become a virtual coach with the help of an app



Runkeeper
iOS/Android, free

This is the go-to app for runners, which tracks all your routes using your phone's GPS whether you're walking, running or even cycling. You can then save and share routes with any other fitness app you might have.



Cardio

iOS, free
Straight from MIT's labs, this app tells you

your heart rate without the need for a cumbersome chest strap. It does this by monitoring minute changes in your face's blood volume via your smartphone's camera.



Medibank Energy Balancer

iOS/Android, Free

Tell this app who ate all the pies and exactly what kind of pies you ate, and it will tell you what kind of exercise you should do and for how long to cancel out your gluttony.

Full Fitness



iOS, £1.49

If you wander into the gym and find yourself perplexed by the muscled choreography of its denizens then this app will clear things up. It shows how to lift specific weights to strengthen whichever muscle you want.

Data including heart rate, stress levels and potential for physical exertion are sent by Bluetooth to your iOS or Android device where the smart-looking app displays the intensity of session your body is capable of, from rest to a vigorous sprint. The coaching feature then prescribes training zones based on that day's heart rate, so you know what rate to train at if you want to burn fat or build speed. It's an impressive piece of kit.

The only moot point is the cost. After three months, you pay a monthly subscription of £7.90. But

compared to wasted gym fees, this could be money well spent.

Unlike the other gadgets on test, the **Powerbreathe K5** actively improves your health, not just measures it – which explains its price tag. It boosts fitness by focusing on the inspiratory system – or 'dumbbells for the diaphragm' as the marketing men tell us. Simply empty your lungs into its mouthpiece and then inhale sharply and for as long as you can. Do this 30 times twice a day for a month before going down to 30 times twice every other day.

The idea is that your diaphragm and ribcage muscles strengthen over time. Like a weights programme, you gradually increase the load to offer greater resistance; in this case, a valve with a variable aperture. The K5 measures a wealth of data including power per breath and peak respiratory flow. It's technical stuff but after four weeks' use my power output when cycling had increased.

Overall, the tools we tested worked well, aside from the Tinké. The Fitbit Pro is useful if

you're new to exercise, while the Omegawave and Powerbreathe K5 are aimed at more committed athletes. If you're serious about monitoring and improving your health, we'd still recommend a heart rate monitor to track your activity, but the tools tested are a great way to optimise what you do in your precious free time. Just be careful of fitness paralysis by data analysis.

JAMES WITTS is the editor of **220 Triathlon** magazine



Accompanies the BBC series *Ice Age Giants* with Alice Roberts



EARTH'S FROZEN PAST

BY JOHN GRIBBIN

From controversial beginnings to irrefutable evidence, it's taken over 200 years to reveal Earth's Ice Ages

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OR HUNDREDS OF years, European people were aware of large lumps of rock, some as big as a house, lying around in places where they didn't belong, far from the strata where such material originated. They became known as erratic boulders, shortened to 'erratics',

and until late in the 18th Century the accepted story was that they had been dumped by the great Biblical Flood.

But in 1787 a Swiss preacher, Bernard Kuhn, suggested that these boulders had been carried to their present locations by ice, not by water. It was natural that this idea should originate in Switzerland, where the power of glaciers was clearly visible, and in the 1790s the Scottish pioneer of geology, James Hutton, reached the same conclusion after a visit to the Jura Mountains of France and Switzerland. But the idea languished until it was taken up and vigorously promoted by another Swiss, Louis Agassiz, who was born in 1807.

Agassiz wanted to study natural history, but to please his parents and

obtain their financial support he qualified as a medical doctor (although he never practised), while also working for a doctorate in natural history, which he obtained in 1829. He became an expert on fossilised fish and a professor at a college at Neuchâtel. It was there he encountered the Ice Age idea.

Agassiz picked up the idea from a geologist, Jean de Charpentier, who gave a talk on the topic in Lucerne at the 1834 meeting of the Swiss Society of Natural Sciences. He reported how heaps of rocky debris, known as moraines, are left behind by retreating glaciers, and speculated that the Swiss glaciers had once been joined in a single ice sheet extending across the mountains and perhaps reaching into the nearby lowlands of Europe. Agassiz thought the idea was ridiculous, and said so to de Charpentier, who was a friend of his.

The upshot was that in the summer of 1836, Agassiz joined de Charpentier on a trip into the mountains to study the evidence at first hand. He went with the intention of persuading his friend to give up this ridiculous

notion of what was called 'ice rafting', but came away converted. Like many converts, Agassiz then became more enthusiastic about the idea than the original enthusiasts, and proposed that there had once been a great ice sheet engulfing Europe all the way from the North Pole to the Mediterranean Sea.

CONTROVERSIAL FINDINGS

By the time the next annual meeting of the Society came around, at Neuchâtel on 24 July 1837, Agassiz was its president, although still only 30. The audience settled into their seats expecting a dull presidential address on fossil fishes, and were astonished when he let rip with an impassioned lecture on the Ice Age, in which that very term was introduced (in German, as 'Eiszeit').

The talk produced a mixture of anger and disbelief. Even when Agassiz organised a field trip to show the members of the Society scars and grooves cut into the rocks by the action of boulders dragged along by glaciers, they dismissed these as damage caused by the wheels of passing



Erratic boulders, left by great glaciers of the Ice Age on Bealach na Gaoithe near Torridon, Scotland

> IN A NUTSHELL

From solving the mystery of giant boulders left scattered across Europe, to intricate calculations describing the motion of the Earth around the Sun, it's taken over 200 years for scientists to discover when and why Earth has periodic frozen epochs.

→ carriages. This only stirred him into more proselytising.

In 1840, Agassiz presented the evidence in a book, *Étude Sur Les Glaciers*, written in language that could not be ignored: 'Europe, previously covered with tropical vegetation and inhabited by herds of great elephants, enormous hippopotami, and gigantic carnivora became suddenly buried under a vast expanse of ice covering plains, lakes, seas and plateaus alike. The silence of death followed... springs dried up, streams ceased to flow, and sunrays rising over that frozen shore...

were met only by the whistling of northern winds and the rumbling of the crevasses as they opened across the surface of that huge ocean of ice.'

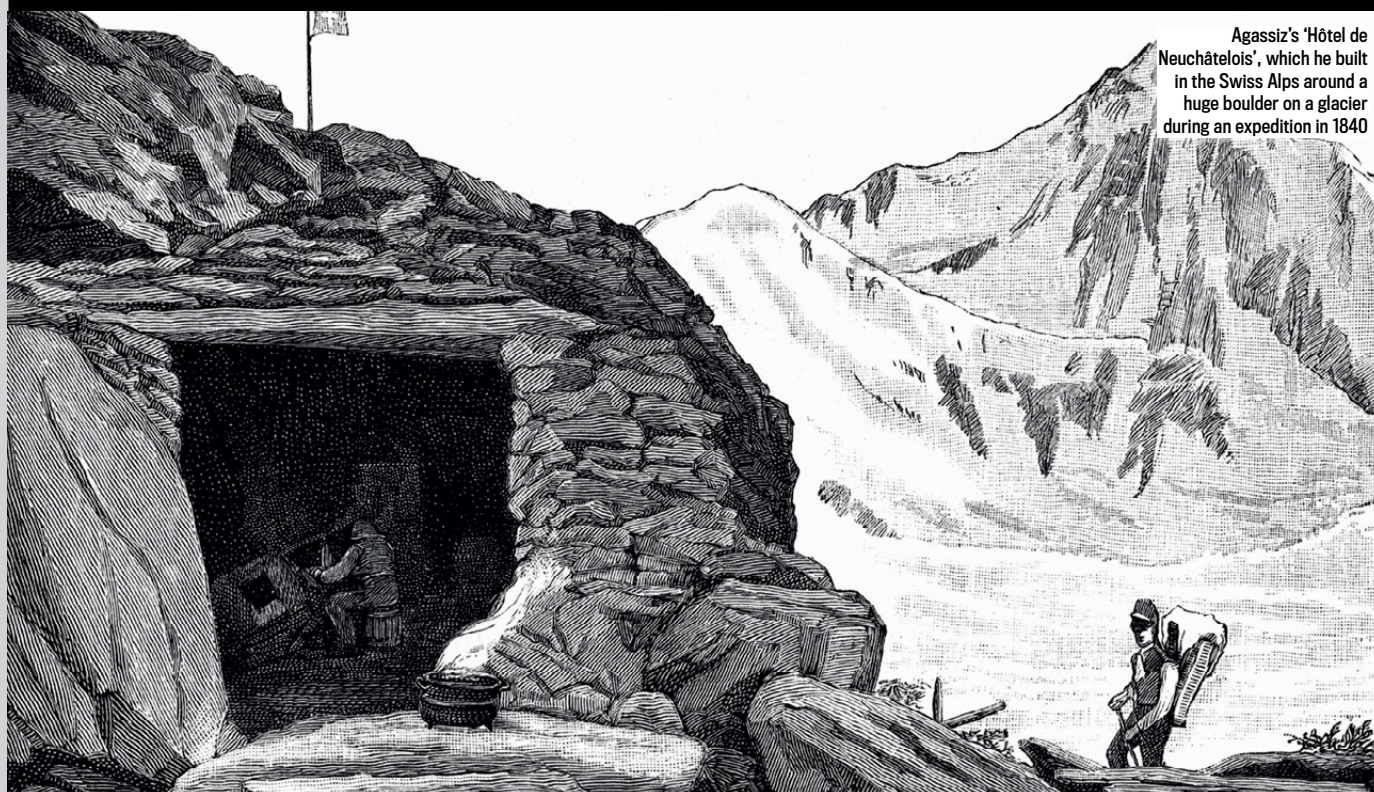
Such language attracted attention, but in scientific terms a much more important event also occurred in 1840, when Agassiz presented his ideas to a meeting of the British Association for the Advancement of Science, held in Glasgow in September. The great geologist Charles Lyell, who was a big influence on Charles Darwin, was in the audience, and like many who heard the Ice Age theory for the first

time, was unconvinced. But as a good scientist, soon after the meeting he headed into the Highlands to look for evidence in the form of 'terminal moraines' left behind by long-melted glaciers, and found them.

Before the year was out, the Ice Age theory had been presented to the Geological Society in London, endorsed by Lyell, and established as fact. The geologists were convinced that the Earth (or at least, Europe) had once been covered by a great ice sheet. But this raised more questions. When had the Ice Age occurred? And why?

THE KEY OBSERVATION

A walk taken by two men in the Alps – one a skeptic, the other entirely convinced of his ideas – was the driving force behind the science that revealed the Ice Ages



Agassiz's 'Hôtel de Neuchâtelais', which he built in the Swiss Alps around a huge boulder on a glacier during an expedition in 1840

The key moment in the Ice Age story came in 1836, when de Charpentier took a skeptical Agassiz up into the Alps. Before then, Agassiz was firmly convinced that erratics were the result of rocks being left by a Biblical Flood. But in the best tradition of science, when confronted with evidence to the

contrary he recanted. As the famous physicist Richard Feynman later said: "If it disagrees with experiment, then it is wrong." This applies to observations as well as to experiments.

Agassiz spent several years studying erratics in the Alps, discovering that some boulders in the area came from as far

afeld as Scandinavia. This is what led him to the idea that a vast area of Europe had once been blanketed in a sheet of ice.

In 1840, history was repeated when the British geologist Charles Lyell set out to see the evidence for himself after hearing Agassiz speak about the Ice Age theory. Once again, he found irrefutable

evidence for the previous existence of a great ice sheet, this time covering Scotland. It came in the form of scars, known as 'parallel roads', along the sides of the valley of Glen Roy, just south of the Great Glen. The 'roads' mark the shorelines of former lakes trapped in the valley by glacial dams.

The seeds of the modern theory of Ice Ages (note the plural) were sown in a book published in 1842, just two years after the Ice Age theory came in from the cold. The author was Joseph Adhémar, a mathematician who worked in Paris, and his book was called *Révolutions De La Mer*. To be frank, it was a confused jumble of good and (mostly) bad ideas, but it contained one golden nugget. This was the idea that the climate on Earth is modulated by changes in the orbit of our planet around the Sun.

SEASONAL EFFECTS

In the 17th Century, Johannes Kepler had realised that the orbit of our planet is slightly elliptical, with the Sun at one focus of the ellipse, which means that at one end of its orbit the Earth is slightly closer to the Sun than when it is at the other end. At present, closest approach occurs in early January, and the Earth is most distant from the Sun in July. So Northern Hemisphere summers are a tiny bit cooler than they would otherwise be, and Northern Hemisphere winters are a tiny bit warmer. But the cycle of the seasons itself is, of course, explained by the tilt of the Earth, which brings us short, cold winter days and long, hot summer days, completely overwhelming this small orbital effect. But Adhémar thought longer term.

Because the Earth travels more swiftly when it is nearer to the Sun, it spends seven days less traversing the (Northern Hemisphere) winter half of its orbit than it does traversing the summer half. In the south, winters are longer than summers. Adhémar argued that over thousands of years this extra length of winter had allowed the vast Antarctic ice sheet to grow. But he also knew that because of a wobble of the spinning Earth (like the wobble of a spinning top), the pattern of the seasons slowly shifts around the orbit of the Earth as the millennia go by. Some 11,000 years ago, Northern winter was seven days longer than summer. And 11,000 years before that, the pattern was the same as today.

Voilà! An explanation of not one but many Ice Ages, alternating in the Northern and Southern Hemispheres. The only snag is, the idea was wrong. The actual amount of heat 'lost' during the seven extra days of winter is nowhere near enough to make great ice sheets grow. But it did set

CAST OF CHARACTERS

The scientists who put their heads above the parapet to prove that Ice Ages took place



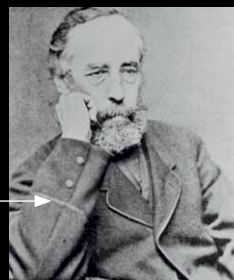
Jean de Charpentier (1786-1855) was a mining engineer, born in Germany as Johann von Charpentier. He adapted his name when he moved to Switzerland to take charge of the salt mines at Bex. His interest in geology led him to study the moraines scattered in the valleys there.



Louis Agassiz (1807-1873) travelled to North America in 1846 to study the local geology and natural history and give a series of lectures. These were so successful that he was offered a permanent job, and stayed in the USA, where he was a major influence on the development of American science.



Charles Lyell (1797-1875) was the pre-eminent geologist of his time. He promoted the 'uniformitarian' idea that the same processes we see today (volcanoes, earthquakes and so on) explain the changes that have occurred during Earth's history. This implied a very long history, allowing time for evolution to work.



James Croll (1821-1890) worked as a carpenter in Glasgow, a travelling salesman, and proprietor of the only temperance hotel in a town with 16 hostels selling alcohol. After his caretaking job, he became a full-time scientist, receiving honorary degrees, and was elected Fellow of the Royal Society in 1876.



Milutin Milanković (1879-1958) also calculated solar radiation data for Mercury, Venus, Mars and the Moon. He worked in civil engineering before taking up a post in Belgrade, where he returned after the War. In 1948 he became Vice President of the Serbian Academy of Sciences.

TIMELINE

It took over 200 years of observations for geologists to reveal the truth about Earth's frozen past



Bernard Kuhn unsuccessfully tries to convince geologists that erratics seen at low altitudes far down Swiss valleys had been **dumped there by retreating glaciers**, implying that the valleys were once full of ice.

1817

1834

Jean de Charpentier gives a talk to the Swiss Society of Natural Sciences on the idea that **glaciers had once covered Switzerland**, the Jura mountains (pictured) and other parts of Europe. Louis Agassiz is in attendance.



Louis Agassiz (pictured) publishes a book dramatically expounding a much bigger vision of **ice stretching from the North Pole to the Mediterranean**. The same year he convinces British geologists including Charles Lyell that the theory is right.

1840

1864

James Croll publishes his first paper on climate change, the start of the development of his idea that very cold winters, produced by **cyclical changes in the Earth's tilt**, are responsible for the onset of Ice Ages.



Milutin Milanković (pictured) calculates how the **'insolation' of the Earth** at different latitudes has changed over thousands of years because of the effects discussed by Croll.

1916

→ people thinking about the orbital influence on climate.

Enter James Croll, born in Scotland on 2 January 1821. Croll came from a poor family and was largely self-taught, reading voraciously about science while supporting himself with a succession of dead-end jobs. In 1859 he was in Glasgow, working for a temperance newspaper when he got his big break – a job as caretaker at the Andersonian College and Museum. The college had a first-class scientific library, which Croll raided while his brother, who was living with him at the time, helped out (unofficially) with his job. In 1861, he published a paper on electricity. Then, he came across Adhémar's book. But he already knew more astronomy than Adhémar.

In particular, he knew that the amount of ellipticity of the Earth's orbit (its eccentricity) changes as time passes, with a rhythm roughly 100,000 years long. He also knew that cyclic changes in the tilt of the Earth affect the relative warmth of the seasons, so that although the total amount of heat received by the Earth from the Sun is the same each year, sometimes Northern Hemisphere summers are particularly cold and summers particularly hot, while at other times there is less difference between the seasons. This pattern repeats with rhythms 22,000 and 41,000 years long.

Croll published his first paper on Ice Ages in 1864, and by 1867 his abilities had been recognised and he got a job with the Geological Survey of Scotland. He developed his ideas over many years, but the final version can be summed up simply. Croll suggested that when Northern Hemisphere winters were particularly cold, snow and ice would spread across the continents, making an Ice Age.

COLD, HARD MATHS

As geologists developed techniques for dating the scars left behind by ice, and other evidence for Ice Ages in the form of past changes in flora and fauna, Croll's idea could be tested, because it is possible to calculate when the orbital parameters made for cold winters. By the end of the 19th Century, they showed that Croll was wrong – wrong in a way which should have grabbed attention, but didn't.

Croll calculated that between 100,000 and 80,000 years ago the world should have been thawing out

NEED TO KNOW

Master Ice Age terminology with this jargon buster

1 ELLIPTICITY (OR ECCENTRICITY)

The amount by which an orbit differs from being circular. A circle has zero ellipticity ($e = 0$). A long, thin orbit is highly elliptical. The Earth's orbit is nearly circular: $e = 0.01671$. For Halley's Comet, $e = 0.967$.

2 ERRATIC (BOULDER)

A piece of rock, anything from a pebble to a block the size of a house, that is different from the bedrock on which it sits. Erratics have been transported, often over long distances, by glaciers or floating ice.

3 INSOLATION

The amount of solar radiation reaching the surface of the Earth or another planet. Insolation is measured in megajoules per square metre (MJ/m^2). The strongest insolation is received at noon each day.

4 TERMINAL MORaine

A moraine is a jumbled heap of debris, rock and soil, found near glaciers or in regions once covered by ice. A terminal moraine is a moraine left behind at the end of a glacier when the ice melts back.

of an Ice Age. In fact, the geological evidence showed that at that time it was plunging into an Ice Age. He had got it exactly backwards. But at first nobody realised the significance – the implication that what you need to start an Ice Age is not cold winters, but cool summers. The person who made this clear was a Serbian mathematician, Milutin Milanković.

Milanković was born in 1879, the same year as Albert Einstein. He was intrigued by the astronomical theory of Ice Ages, and worked on how the changes in tilt and wobble had affected the amount of heat reaching the ground at different latitudes (insolation) in his spare time from being a Professor of Mathematics in Belgrade.

In 1914 he was unlucky enough to be visiting his home town in Serbia, the



An artist's impression of how the Earth would have looked at the peak of the last Ice Age, with northern Europe blanketed with ice

wrong side of what became the front line, when World War I broke out. Interned by the Austro-Hungarians, he had nothing to do except calculate, on paper using a fountain pen. It took him two years to come up with a model describing how the insolation had changed over the millennia for each band of latitudes on Earth. His results were published in 1920, and soon after reading them Wladimir Köppen, a Russian-born German meteorologist, realised that they showed how Ice Ages are associated with cool summers.

It is always cold enough for snow to fall in winter, but what matters is that sometimes summers are too cool for all the snow to melt before winter comes again. The resulting Ice Age only ends when very hot summers return to melt the ice. All of this was confirmed

in exquisite detail in the 1970s, from analyses of deep sea sediments and long ice cores from Greenland and Antarctica. What we now know is that Ice Ages roughly 100,000 years long are separated by slightly warmer 'interglacials' about 10,000 years long, and that the present interglacial began about 10,000 years ago. If it were not for global warming, the next Ice Age would be just around the corner. ■

John Gribbin is a science writer and co-author of *Ice Age* (Allen Lane)

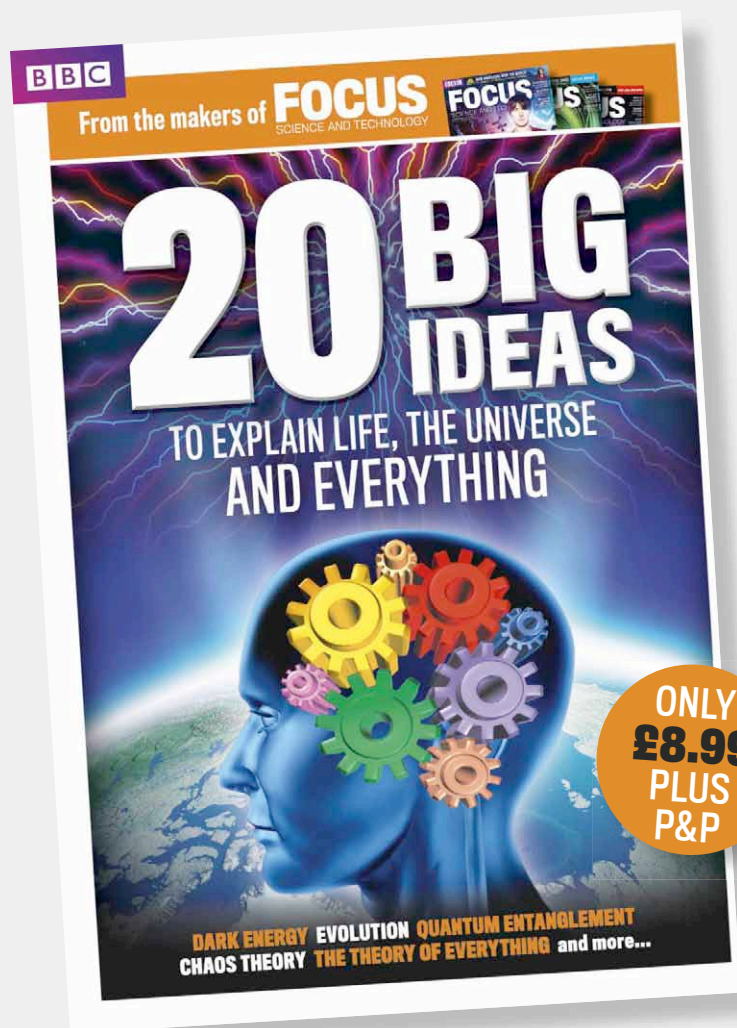
Find out more

 Listen to *Ice Ages*, an episode of *In Our Time* with Melvyn Bragg
<http://bbc.in/13sT14P>

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TO DO LIST

PLAN YOUR MONTH AHEAD WITH OUR EXPERT GUIDE

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-  **TOUCH**
-  **PLAY**
-  **READ**

PICK OF THE MONTH



Horizon: Tomorrow's World

Liz Bonnin asks what's really driving technological innovation in the 21st Century

→ DON'T GET CONFUSED: this isn't a revival of the BBC's old gosh-wow technology show. Instead it's Liz Bonnin in the Science Museum's huge warehouse near Swindon, surrounded by the inventions of the past, talking about the inventions of the future. But not for long. Soon she's off to talk to today's inventors, engineers and scientists hard at work solving humanity's future challenges, and their personalities alone make the show worth watching.

Manchester University's Andre Geim shows off by apparently drinking liquid nitrogen, relaxes by levitating frogs, then invents graphene using items you could find on a child's desk. Meanwhile in California, Bob Richards is making a robot to land on the Moon and win him the Google Lunar X Prize.

Between the intriguing and uplifting stories, there are brief pauses to reflect on what makes innovation happen. Prizes worked for Charles Lindbergh flying across the Atlantic, and seem to be spurring the new private space race too. But these big-money R&D grants often rely on big government

spending: Richards' Moon Express team, for instance, is using NASA leftovers to test its lander. The internet and 'open hardware' also get credit for spurring creativity, with a \$33,000 crowd-funded flexible boat the poster child for non-commercial collaboration. But if everything is shared for free, how can investors get their money back?

Commercial imperatives drive the search for alternative energy sources, such as the desert lab where one of the planet's oldest life forms has been genetically modified to turn sunlight and CO₂ into ethanol. We can't see "put a cyanobacterium in your tank" catching on as a slogan, but it's a cheering reminder of our capacity to solve problems by imagining solutions and then making them happen.

TIMANDRA HARKNESS



Horizon: Tomorrow's World will be shown on BBC Two on 11 April at 9pm

DON'T MISS!



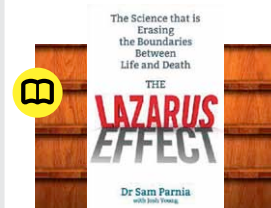
Maker Faire

Build your own poledancing robot and much more at this annual gathering of British inventors **p98**



Chasing Ice

The story of one man's quest to document climate change using time-lapse photography **p101**



The Lazarus Effect

A leading resuscitation specialist claims to have scientific proof that there is an after-life **p104**



VISIT

EVENTS & EXHIBITIONS

WITH JHENI OSMAN

11 APRIL

CSI: Harbourside!

At-Bristol, 6.30pm-10pm, £7 (concessions and members £6), www.at-bristol.org



NO, THIS ISN'T the result of budget cuts to the TV show *CSI: Miami*, it's a new forensic science-themed evening for adults where it's up to you to work out 'whodunnit'. Just like the eponymous TV show, forensic experts are on hand to help you gather evidence from the crime scene, interview witnesses and analyse CCTV footage, with prizes for those identifying the criminal correctly. The price also includes a planetarium show and museum entry.

16 APRIL - 21 MAY

Aliens In Science Fiction

Royal Observatory Greenwich, London, Tuesdays 7pm-9pm, £72, www.rmg.co.uk/royal-observatory



FROM CUDDLY *ALF* to *Alien's* Xenomorph, fictional aliens have been as varied as our imaginations. But what makes a truly great science-fiction extra-terrestrial? This short course, which will appeal to science fiction fans and budding writers alike, explores the development of aliens in science fiction through literature, art, film and TV, and discusses the ways in which science, imagination and culture meld.

16 APRIL - 28 MAY

Food And Nutrition

Life Science Centre, Newcastle, Tuesdays 7pm-9pm and Saturday 16 May 10.30am-1pm, £45, www.life.org.uk

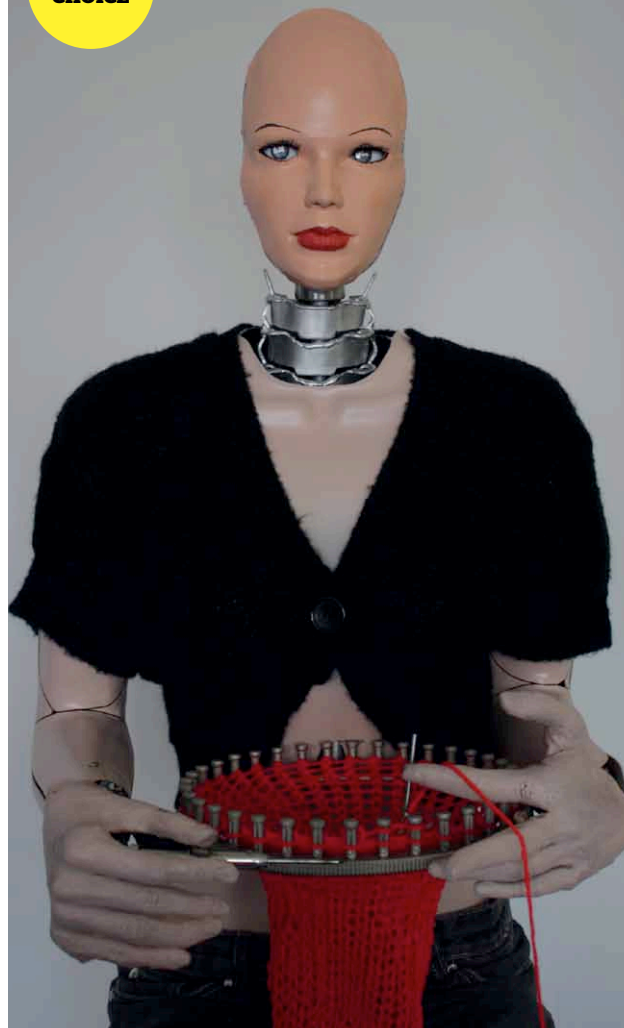


AS WE WENT to press the horse meat scandal was still racing on (sorry), so it's never been more important to know exactly what you're eating. You are what you eat, but who wants to be a Shetland pony? This bite-sized lecture series promises to help make sense of all the contradictory and confusing information out there, explaining modern food processing methods and revealing the science of a healthy diet.

JHENI OSMAN is a science writer and the author of *100 Ideas That Changed The World* (BBC Books, £9.99)

EDITOR'S CHOICE

Poledancer, pancake chef or killer crochetbot? Head down to Maker Faire to find out



27-28 APRIL

Maker Faire

Centre For Life, Newcastle, www.makerfaireuk.com

➔ OUR ATTEMPTS AT 'DIY' typically end with a piece of flat-pack furniture that falls apart when the cat sneezes. But if you're an amateur inventor, or want to become one, then this year's Maker Faire festival is worth leaving the garden shed for.

The show celebrates everything that's great about making things yourself, from repairing simple electronics to building your own pole-dancing robot (we're guessing roboticists maybe don't get out much). The festival hosts

new inventions from over 300 fellow enthusiasts, workshops to get you started as a 'maker' and enough fire-breathing contraptions to make a health and safety officer sweat.

Once we've visited the pancake-bot for our breakfast, our first stop will be the biotech section of the Faire. Here you'll be able to kiss a petri dish to see the bacterial ecosystem living on your lips, and discover how the most cutting-edge inventors have swapped their physical toolkit for a biological one.

18 APRIL

Where The Streets Have No Name

Royal Society Of Chemistry, London, 6.30pm, free, booking required, www.rsc.org

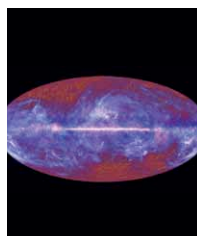


DRIVING A MARS rover must be one of the few jobs better than The Stig's. Paolo Bellutta from NASA's Jet Propulsion Lab has been a rover driver for nine years, first for Spirit and Opportunity and now Curiosity. At this talk, he reveals the challenges of operating rovers on the Red Planet – pelican crossings must be a nightmare, what with all those little green men everywhere.

20 APRIL

The Big Bang Seen By The Planck Satellite

MOSI, Manchester, www.mosi.org.uk



SINCE 2009, THE Planck Satellite has been surveying the sky. Its mission: to analyse a faint glow that fills the Universe, known as the Cosmic Microwave Background (CMB). The ripples in the CMB are signatures of events that took place in the milliseconds after the Big Bang, and later developed into the stars and galaxies we know today. Visit this Saturday Science event to find out the first results – hot off the press.

2 MAY

Risk

Science Gallery, Dublin, 2 May-23 June, sciencegallery.com/2013



RISK ISN'T JUST a board game, it's a fact of life. This exhibition uses neuroscience, genetics, psychology and maths to explore our relationship with probability and luck. Through experiments devised by David Spiegelhalter (pictured), Winton Professor of the Public Understanding of Risk at Cambridge and presenter of BBC Four documentary *Tails You Win*, you can explore your own ability to perceive and assess risk.

8 MAY

On The Organic Law Of Change

Natural History Museum, London, 4.30pm-5.30pm, www.nhm.ac.uk



Victorian naturalist Alfred Russel Wallace was planning to write up his observation notes into a book called *On The Organic Law Of Change*, but abandoned it when Darwin published *On The Origin Of Species*. At this talk, Dr Jim Costa, Professor of Biology at Western Carolina University, discusses the development of Wallace's ideas on evolution, leading up to his independent discovery of natural selection.

SPEAKER OF THE MONTH

16 APRIL

Adam Rutherford

Royal Institution, London, 7pm-8.30pm, www.rigb.org



Who is he?

The last time we met Adam he was telling us about spidergoat – not a new superhero but a goat he'd met while filming for BBC *Horizon*. The goat had been altered genetically so its milk could be used to create artificial spider silk. As a geneticist, Adam is interested in how nature can provide us with tools to solve all kinds of problems.

What's he talking about?

Life. What is it? Where did it come from? And how? Adam explains how advances in experimental biology have answered some of these questions. He also peers into a future where synthetic biology creates completely new life forms in the lab, offering tailor-made solutions to looming crises such as pandemics and climate change.

UNTIL 27 APRIL

Signs, Symbols, Secrets

Science Museum, London, free, www.sciencemuseum.org



Somewhere in this picture is the key to turning lead into gold. Or maybe not...

MEDIEVAL ALCHEMISTS BELIEVED the philosopher's stone would turn base metals into silver and gold, heal the sick and perform umpteen other miracles. The hunt for it became an obsession, and to shield their 'discoveries' from prying eyes, alchemists recorded them in pictures, using complex codes of signs and symbols. This exhibition features over 20 of these incredible images, including a Ripley scroll – one of just 23 known to exist – that was recently found lurking in the Science Museum's own archives.



WATCH

TV, DVD, BLU-RAY & ONLINE
WITH TIMANDRA HARKNESS

APRIL TBC

Timebomb Iceland

Channel 5, April TBC



IT TOOK JUST one Icelandic volcano to ground air traffic across half the globe. Scientists and historians are now studying Eyjafjallajökull and its neighbours, probing deep beneath the surface. Hundreds of metres down, molten rock is stirring – and three neighbouring volcanoes could make Eyjafjallajökull look like a sparkler. Hekla and Laki have erupted without warning before, spreading destruction as far as mainland Europe, and now the biggest of them all, Katla, is stirring in its sleep.

APRIL TBC

Motor Morphers

Channel 5, April TBC



WHY, YOU ASK, has nobody ever crossed *Scrapheap Challenge* with *Transformers*? Well now you need ponder no more, as Jason Bradbury moonlights from *The Gadget Show* to host this mechanical challenge show. Each week, two teams of engineers are given the task of converting a utility vehicle into something else in just four days. That concrete mixer that always dreamed of becoming a speedboat is about to fulfil its ambition. They say “guerrilla engineering”, we say “show us the Risk Assessment on THAT”.

7 & 11 APRIL

The Sky At Night

BBC One, 7 April and BBC Four, 11 April



THE LONG-RUNNING monthly astronomy programme returns with a topical special on asteroids, meteors and meteorites. If you missed asteroid 2012 DA14, which recently passed close to Earth (and hopefully the meteor that decided to pay Russia a closer visit), you can catch up with them now. Find out what meteorites are, where they come from and why scientists get so excited about them. The show features Caroline Smith of the Natural History Museum and astronomer and presenter Chris Lintott.

TIMANDRA HARKNESS is a stand-up comedian and a presenter on BBC Worldwide's YouTube channel Head Squeeze

Dr Helen Czerski:
she's having a
bubble, matey

EDITOR'S
CHOICE



APRIL TBC

Bubbles

BBC Four, April TBC



YOU'VE DOUBTLESS seen physicist Helen Czerski on television numerous times before – perhaps doing missions for *Dara O Briain's Science Club*, getting drenched by a monsoon in *Orbit*, dodging polar bears in *Operation Iceberg*, or driving a van in *Transit Of Venus*. You've read her monthly column in *Focus*. Now, at last, you get to see Dr Czerski discussing her own specialist subject: bubbles.

As an oceanographer, she studies bubbles in the wild. So we're hoping for lots of exotic locations, with the brave doctor jumping off research ships and scuba diving in search of the shy, elusive bubble. But she also keeps research bubbles in a tank back at her lab in Southampton University, so she can get down to the really interesting stuff like optics and acoustics.

“It's much easier to measure the characteristics of tiny bubbles when you don't have to float about beside them at the same time,” she says.

But can you really make an hour-long documentary about bubbles? What is there to say about them? Well, they're important in vital things like transferring gases between ocean and air, and scattering tiny droplets called aerosols into the atmosphere. Dolphins use them, and they make surfers look cool and rad.

Beyond the ocean, bubbles have all sorts of uses – from medicine to keeping your bath water warm for longer. Most important of all, they're what makes champagne so special. And Dr Czerski, a dedicated researcher to the last, is prepared to take one for the team and get to the bottom of the mystery. And the bottle.

FROM 19 APRIL

Perfect Storms: Disasters That Changed The World

Yesterday, starts 19 April, 9pm



In 9AD the severed head of Roman general Varus was sent back to Rome in a box after three legions were ambushed in a German forest during a catastrophic thunderstorm. The mighty Empire never tried to conquer the northern tribes again. As this series shows, natural disasters can have a dramatic impact on human history. From earthquakes to blizzards, armies as mighty as Hitler's have been defeated, governments toppled and civilisations brought low by nature's tantrums.

20 APRIL

Chasing Ice

National Geographic, 20 April, 8pm

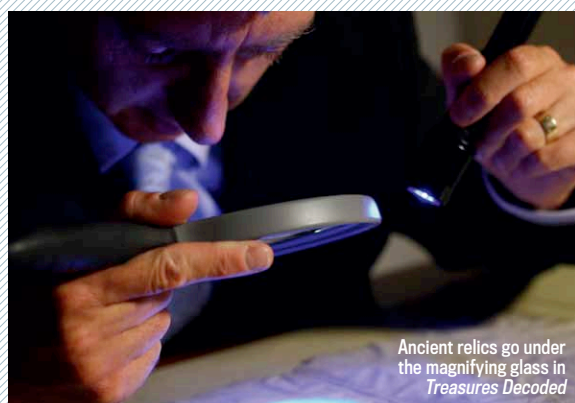


NATIONAL GEOGRAPHIC PHOTOGRAPHER James Balog set out to document the changing face of ice across the planet. His Extreme Ice Survey took him to some of Earth's most challenging environments, stretching him and his equipment to the limits. The resulting footage from 25 time-lapse cameras compresses years of glacially slow movement into minutes.

FROM 21 APRIL

Treasures Decoded

Quest, starts 21 April, 9pm


 Ancient relics go under the magnifying glass in *Treasures Decoded*

➔ LIKE SOME KIND OF *CSI: Ancient World*, this five-part series applies modern forensic science techniques to ancient mysteries. The Dead Sea copper scroll, the Jordanian lead codices and the golden raft of El Dorado won't hold out for long under this kind of interrogation. Let's face it, they weren't designed to withstand 21st Century scanning techniques and microscopic analysis. This time, the Sphinx will be the one answering the questions, and the Turin Shroud will unwrap its secrets...

DVD & BLU-RAY



Through The Wormhole With Morgan Freeman Season 3

Go Entertain, £14.99

THIS SERIES CLAIMS to bring together the best minds in astrobiology, quantum mechanics and string theory to answer life's hardest questions. Can we eliminate evil? What is nothing? Is there a superior race? (MotoGP - Ed.) However, we all know the truth: you can assemble the world's biggest brains, but the fact is that whatever Morgan Freeman says, we'll believe him.



James Cracknell: World's Toughest Expeditions

Demand Media, £8

SEE A MAN swim the flooded Xingu River, home to anacondas and piranhas. Why? Because he's James Cracknell, and he won't be happy until he's recreated the toughest expeditions in history - including those where the explorers died.



Ancient Aliens Season 3

History, £18.70

ZOMBIES? VAMPIRES? WHATEVER the myth, it seems it can be explained by a simple, logical idea: aliens visited us from space. This being Season 3, pyramids, Nazca drawings and all the other usual suspects have largely been covered. We're hoping that now they'll mop up the outstanding questions, like where the missing socks go.

28 APRIL

Secret History Of UFOs

National Geographic, 28 April, 9pm



FROM THE ROSWELL Crash to a 1997 apparition over Phoenix, UFOs have long intrigued us. Most 'sightings' are explained by aeroplanes, lanterns or unusual weather, but a few remain mysterious. It includes interviews with those who claim aliens abducted them and a US Air Force officer who joined his men chasing strange lights in East Anglia, this documentary charts the strange history of UFOs.

APRIL TBC

Dara O Briain's Hard Sums

Dave, April TBC



YOU DON'T NEED a degree in maths and physics to host *Mock The Week*, but if Dara O Briain is anything to go by, it helps. Now the show that puts him together with mathematician Marcus du Sautoy to tackle arduous arithmetic and tricky trigonometry returns for a second series. Each episode will feature a guest comedian and a new challenge that can only be solved using maths. Protractors at the ready!



LISTEN

BBC RADIO PROGRAMMES

WITH TIMANDRA HARKNESS

1 APRIL

Discovery: Premiership Science

BBC World Service, starts 1 April

LIKE FOOTBALL, SCIENCE is an international arena in which the star players are rewarded with wealth, fast cars and the adulation of millions. Okay, no, scientists *don't* get the rewards that footballers do, but they have traditionally worked all over the world. Until recently. In this two-parter, *Guardian* journalist Alok Jha asks why the international movement of the finest minds has slowed in recent years, and considers what can be done to re-open the transfer window.

9 APRIL

Human Zoo

BBC Radio 4, 3pm

CATCH THE FINAL episode in Michael Blastland's series about how we think and why we behave the way we do. "In the lab, not on the couch" is his motto, as he interviews researchers, becomes a human guinea pig, and generally lets his mind wander through experimental psychology. You may hear from some woman called Timandra Harkness too, whoever the hell *she* is...

15 APRIL

Discovery: Life On Mars

BBC World Service, starts 15 April

DOCTOR AND SPACE enthusiast Kevin Fong has spent a lot of time thinking about what it would take for humans to live on

other planets. Across two programmes he imagines what life in a Mars colony might be like, and then looks at how artists and science fiction writers have pictured life on the Red Planet. Have their ideas influenced the design of real space exploration projects?



The first Mars colony could look like this

8 MAY

Don't Log Off

BBC Radio 4, starts 8 May

ALAN DEIN, THE man who made a radio series from calling random numbers late at night and recording the conversations, returns with a second series of the digital age reboot. Strangers on social networking sites have stories to tell, and Alan wants to hear them and share them with us.

9 MAY

State Of Play

BBC Radio 4

COMPUTER GAMES GIVE hours of harmless fun, but playing them is never going to save the world in real life – is it? Alex Butterworth enters the world of transmedia and pervasive gaming to find out how playing games might hold the potential to solve real problems. So next time somebody looks askance at your 18-hour *Call Of Duty* marathon, tell them you're practising to save the world.



TOUCH

SMARTPHONE & TABLET APPS

WITH CHRISTOPHER PHIN



Tl-Nspire

iPad

Texas Instruments Inc, £20.99

IT'S A SAFE bet that anyone reading *Focus* has either owned or been jealous of someone who owned a Texas Instruments graphing calculator, but if you want one these days, it could cost you £150. Or, if you have an iPad, 21 quid – for an app that is spectacularly rich, and easier to get to grips with on the iPad's bigger screen. It's not pretty, and it's not easy to use, but from interactively modelling, say, energy conversion, to entering complex algebraic formulae or analysing statistics, it's an astonishing tool to have at your disposal.



Bridge Constructor

Android 2.2 or later

ClockStone STUDIO, £1.45

YES, IT'S A game, but don't feel guilty – there's some solid physics at the heart of it. You're given a range of chasms to span with a bridge of your own design, using a given set of materials – wood, concrete and steel cable, for example – and to a budget. It seems simple, but as soon as you start running traffic over your creation, stresses show up in the joints so you can see where you're going wrong. A little fiddly, but huge fun. Sorry, we meant hugely educational!



Oh No Fractions!

iPhone, iPod Touch, iPad

Curious Hat Inc, free

THIS SEEMS LIKE a throwaway, simple little app for kids, and we were all set to dismiss it as such when we decided to give it a go anyway on a whim – and found there's just something about it that keeps you having one more go. Here's what it does: you're given two fractions – 3/7 and 2/3, say – and you have to say which is bigger. You can have a peek at the answer, or drag sliders to confirm once you've answered right or wrong. That's it. And yet we can't stop! 3/4 or 2/8? Easy, 3/4! 3/5 or 4/7? Eas... no wait, hang on...

CHRISTOPHER PHIN is the editor of *MacFormat* magazine



PLAY

CONSOLE & COMPUTER GAMES

WITH NEON KELLY



Injustice: Gods Among Us

PS3, Xbox 360, Wii U, Warner Bros. Interactive, £39.99

THIS GAME BRINGS together some of the biggest names in DC Comics, then goads them into smacking the living daylights out of each other – it's the gaming equivalent of that kid at school who was always provoking fights and then running away when the teacher showed up. While hardcore gamers will stick to *Street Fighter IV*, this offers the chance to duff up The Joker as Batman, or to pitch Wonder Woman against Lex Luthor. Take that, slaphead!



Deadly Premonition: Director's Cut

PS3, Rising Star Games, £26.34

DEADLY PREMONITION IS one of the best and worst games you'll ever play. The graphics are woeful, the controls are sloppy, and it's a massive rip-off of *Twin Peaks*. On the other hand, it's also a game where you control an unhinged FBI agent whose beard grows if you don't shave him. It's hilarious, creepy and utterly baffling – the definition of a cult classic. This new version fixes a few flaws, but it's still something of a curate's egg.



Star Command

iOS / Android, War Balloon Games, £2.99

AS WITH RECENT *Focus* favourite *FTL: Faster Than Light*, *Star Command* places you in charge of your very own starship. But where *FTL* focused on your ever-vulnerable craft, *Star Command* is all about your crew – cute little folk in coloured jumpsuits. You'll order them about your vessel, assign them jobs and beam with pride when they get promoted. And then you'll openly weep when they get vaporised by invaders. It's a sci-fi tragicomedy delivered in bite-sized portions – ideal for your daily commute.



EDITOR'S CHOICE

In reality Clooney and his suave crew of thieves in *Ocean's Eleven* would have spent 50 years in a supermax prison; it's much safer to rob a casino from the comfort of your sofa

Monaco: What's Yours Is Mine

PC, PS3, Xbox 360, Pocketwatch Games, £14.99



It's the distinctly odd art style that's likely to grab your attention first. *Monaco's* levels resemble a set of black-and-white blueprints, viewed from above. As your diminutive crook scampers around the level, the world bleeds into colour according to what they can see; moving into a new room will cause it to bloom into life, just as the path behind you fades to a monochrome gloom.

At first this aesthetic may seem confusing, but once it clicks you'll see *Monaco* for what it really is: a stealth game where uncertainty and chaos lurk around every corner. If you're blessed with skill and luck then everything will run like clockwork, but it's far more likely that something will slip. An alarm gets tripped, the guards swarm in, and suddenly you're scrabbling to save your no-good hide.

There's a whole rogue's gallery of scoundrels to play as, ranging from a charming impersonator (think Tom Hardy in *Inception*) to a pickpocket with a malevolent pet monkey. Up to three friends can join you on a heist too, but never forget – there's no honour among thieves.

➔ HAVE YOU EVER watched *Ocean's Eleven* and thought, "Hey, I could do that!"? Well, you probably couldn't, but it's certainly fun to make believe. Just picture it: the glamour, the danger... the Hollywood A-listers goofing around in expensive hotels...

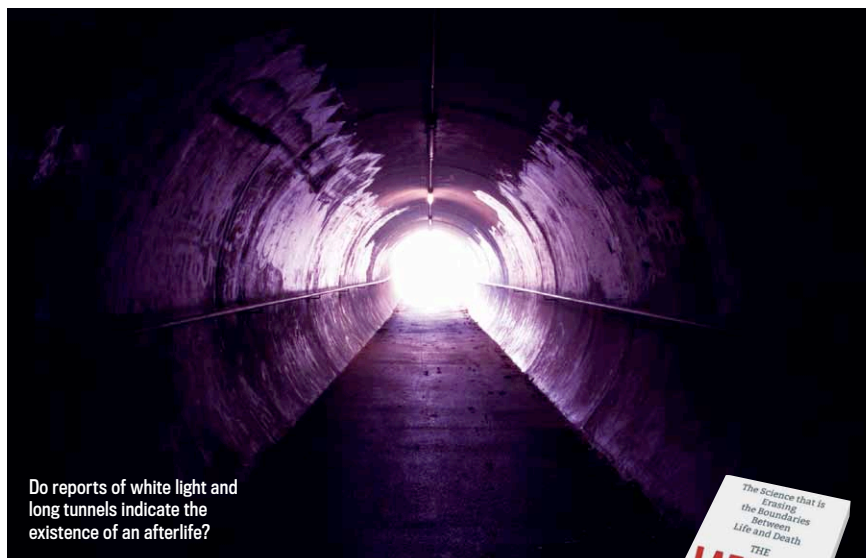
Well, *Monaco* won't let you clink glasses with George Clooney or Brad Pitt, but it will let you indulge your daydreams of being a master thief. And just like any good heist movie, much of the fun lies in the fact that your carefully laid plans will invariably go wrong. *Monaco* doesn't just flirt with disaster, it sweeps disaster off its feet and gives it a whopping great snog on the lips.



READ

THE LATEST SCIENCE BOOKS REVIEWED

H Hardback **P** Paperback



Do reports of white light and long tunnels indicate the existence of an afterlife?

The Lazarus Effect The Science That Is Rewriting The Boundaries Between Life And Death

Dr Sam Parnia with Josh Young

Rider **P** £14.99

DR PARNIA IS a resuscitation specialist, a medical professional with a deep knowledge of the body systems that support life. Along with Josh Young, he has written a scientific adventure story that is well informed and gripping. It is also fundamentally wrong-headed.

Mixing tales from the emergency ward with the latest medical research, Parnia reveals how a battle against the factors which damage the body during the death process has made it possible to push back the point at which people can be restored to life. People are brought back to life hours after their hearts and all medical signs have stopped. Accompanying this medical 'miracle' is an increase in the number of people who report near-death experiences. Dr Parnia discusses the remarkable similarities among these reports (tunnels, white lights, encounters with benevolent beings), as well as related research concerning out-of-body experiences and consciousness during coma.

This is where the book goes wrong. The research is fascinating and clearly presented, but Parnia wants to interpret it as showing that consciousness persists independently of life and brain activity. These experiences are genuine reports of an afterlife, he claims. I'm sceptical.

The plural of anecdote is not data: 100 people telling you they have fairies living at the bottom of their gardens isn't good evidence, even though it is 100 people. Psychology research shows that false memories and confirmation bias are common factors, often producing unreliable accounts, especially for events in which awareness is disrupted. Also, many who have 'near death' experiences are not really near death. You need hard evidence for remarkable claims. When he's off the topic of emergency care, Parnia doesn't provide it.



DR TOM STAFFORD is a psychologist and the co-author of *Mind Hacks*

MEET THE AUTHOR



Sam Parnia

What's the book about?

The book focuses on two main areas. Firstly, we've made enormous advances in being able to push back the boundaries of death and bring people back to life even many hours after they've died. But the standards of care that these patients receive are very variable and often substandard. So the focus is on trying to make the public aware that there's a lot we need to do to elevate the level of care that people get. Secondly, through our efforts to push back the boundaries of death, we've come to understand that human consciousness doesn't become annihilated after somebody dies, but continues to exist for a number of hours.

How did scientists discover this?

This is an inadvertent consequence of the work that we've done in resuscitation. In order for us to rescue somebody, we've had to step beyond the threshold of death and enter into the period that corresponds with what happens after we die. We've found that a cessation of oxygen to the brain can cause human consciousness to, in effect, hibernate. People who we have resuscitated many hours after death have come back with their consciousness still present, just like someone who's had a general anaesthetic for several hours.

Is there anything that science can't tell us about death?

There will always be aspects of reality that remain outside our scientific understanding. But we've started to shed light on questions such as 'Who am I?' and 'What happens when we die?' and that's a very exciting prospect.

MORE ON THE PODCAST

Listen to the full interview with Sam Parnia at sciencefocus.com/podcasts



Paleofantasy

What Evolution Really Tells Us About Sex, Diet And How We Live

Marlene Zuk

WW Norton & Company **H** £17.99

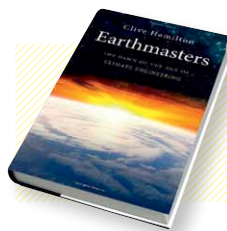
NOSTALGIA, SO THEY say, isn't what it used to be. Adverts and the internet are overstuffing with paeans for the Good Old Days. To be specific: to the Stone Age. A time when human beings only ate 'natural' foods and got plenty of exercise, before agriculture came along to ruin things with its restricted and starchy diet and sedentary habits. How we yearn for our Palaeolithic peak, when men were men and mammoths were nervous. Our constitutions are Palaeolithic, unsuited to our fretful modern lifestyles. It says so in our genes.

Au contraire says Marlene Zuk in this refreshing book. Human evolution didn't stop in the Palaeolithic. Why would it? Evolution is the moving finger. Having writ, it moves on, just as it did when we were climbing trees or swimming in the primordial slime. We are now as genetically mismatched to the 'paleofantasy' of Stone Age life as giraffes are to unicycles.

As such, *Paleofantasy* is a necessary corrective to so much new-age nincompoopery. Besides, you've got to love any book that starts: 'the first thing you have to do to study 4,000-year-old DNA is to take off your clothes'.



HENRY GEE is a biologist, senior editor of the journal *Nature* and *Focus* columnist



Earthmasters

The Dawn Of The Age Of Climate Engineering

Clive Hamilton

Yale University Press **H** £20

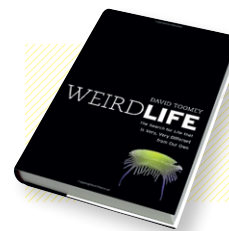
WHILE THE ISSUE of climate change may have slipped down the political agenda, the problem of global warming remains. One day, Hamilton says in this superb book, we will realise that the question has changed. It is no longer a matter of whether we can prevent a climate crisis, rather if we can cope with the effects.

Geoengineering is one way to try. In its broadest terms, it encompasses all the possible techno-fixes that could help us escape rising temperatures. They are all discussed here – from sucking carbon dioxide from the air to spraying chemicals into the atmosphere to block sunlight.

What makes this work stand out is its exploration of the people, politics and power that lie beneath. From the nuclear weapons scientists of the Cold War to wealthy philanthropists, Hamilton shows how control over the atmosphere is a seductive and enduring fascination. And, like one of the mirrors that could be erected in space to bounce back sunlight, in the dynamics of geoengineering we can see reflected the special interests, money, power and societal blinkers that got us into this mess in the first place.



DAVID ADAM is operations editor at the journal *Nature*



Weird Life

The Search For Life That Is Very, Very Different From Our Own

David Toomey

WW Norton & Co **H** £17.99

THIS BOOK COULD only have been written in the last few years, now that we've come to appreciate the sheer diversity of life on Earth, and the possibility of something altogether weirder.

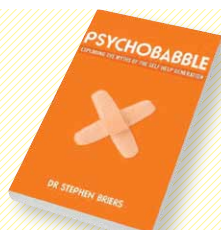
By first explaining the molecular machinery that drives life as we know it and the 'extremophile' organisms tolerating the most hostile environments, Toomey is then able to discuss ways in which other life might be considered to be weird (at least compared to us!). For example, life might use a chemical other than DNA, or something other than water to fill its cells, like liquid methane.

And as Toomey argues, this isn't merely idle speculation – by understanding the limits of terrestrial life we gain crucial insights into the possibility of extraterrestrial life: organisms inhabiting perhaps Mars, or the moon Titan.

In the later chapters, Toomey allows himself to venture into the realms of science fiction, which makes for a fascinating aside. He discusses the feasibility of machine life, or organisms residing right on the brink of a black hole to sip the trickle of available energy.



LEWIS DARTNELL is an astrobiologist and the author of *Life In The Universe*



Psychobabble

Exploding The Myths Of The Self-Help Generation

Dr Stephen Briers

Pearson **P** £10.99

THIS IS A wonderfully provocative book, attacking the many myths of popular psychology. 'Is our culture of self-help really helping,' Dr Briers asks, 'or is it just creating expectations that none of us can live up to?' From the title you can guess how he answers that question. He is honest enough to admit that as a clinical psychologist, his clients have had to put up with his own 'psychobabble' and he has even written the odd self-help book.

But he doesn't just pick on obvious targets such as 'you can do anything you want' or 'your inner child needs a hug'; he also raises questions about mainstream

psychology, including the effectiveness of cognitive behavioural therapy (CBT). He acknowledges the contribution that CBT has made to our understanding of the mind, but makes a convincing case that it's not all it is sometimes cracked up to be.

I would have preferred it if he had spent longer on fewer chapters, but this is fascinating reading for anyone who has ever wondered about the reality behind the claims of the self-help industry.



MICHAEL MOSLEY is a writer, doctor and BBC science presenter

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MINDGAMES

BBC FOUR Pit your wits against these brainteasers by David J Bodycombe, question-setter for BBC Four's *Only Connect*

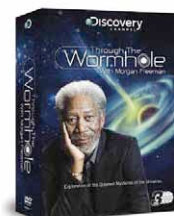
PRIZE PUZZLE

What unusual property do the words **CHILD** and **QUIZ** have in common? (Hint: three.)

WIN! THROUGH THE WORMHOLE ON DVD

The first five correct entries win a copy of *Through The Wormhole With Morgan Freeman* on DVD (Discovery).

Post your entry, marked 'Prize Puzzle 254', to: *Focus* magazine, PO Box 501, Leicester, LE94 0AA, to arrive by 5pm on 2 May 2013. We regret that we cannot accept email entries for this competition. See sciencefocus.com/winners for a list of previous winners and solutions.



See bottom of p104 for terms and conditions. Congratulations to Lorna Applah (Newcastle), G Pitcher (Gloucester), Diana Hancock (West Yorkshire), Jason Culligan (County Clare) and Robert Stewart (Bristol), who all answered the February Prize Puzzle correctly to each win a copy of *Attenborough's Anthology* on DVD.

Q1

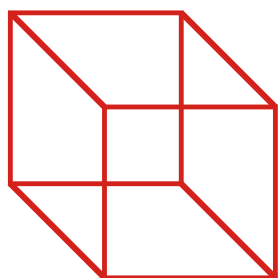
In which context is Au worth one-third of Pt, and Ag worth three-fifths of Au?

Q2

Which eight-letter word can you form from eight of ABCDEFGHIJ and K?

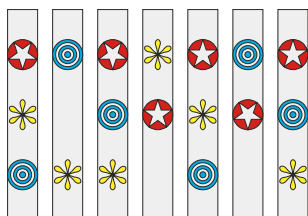
Q3

How many edges of this cube need to be removed so that what remains can be traced without taking the pen off the page or retracing?



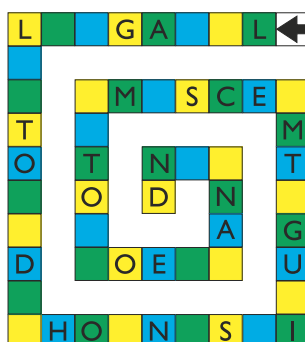
Q4

Which three sticks need to be turned upside-down so that the three horizontal rows contain the same set of symbols (in some order)?



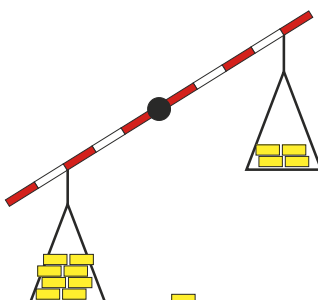
Q5

Moving four or seven squares (forwards or backwards) at every stage, what phrase can be spelt out here?



Q6

You have a balance and 13 coins, as shown. Given that each pan weighs the same as one gold coin, move just one coin so that the scale balances.



Q7

What connects a clockwork watch, a dance floor, a surprise and a prisoner from jail?

Q8

In this Hitori puzzle, sufficient squares must be shaded in so that no row or column contains the same digit twice. The shaded squares cannot be next to each other horizontally or vertically, but can touch at corners. Once complete, all the white unshaded squares remain connected - i.e. it is possible to travel from one white square to any other by horizontal and vertical moves.

8	4	3	4	4	9	1	2	6
4	7	9	1	5	2	6	3	8
4	8	5	2	2	5	3	5	7
7	1	2	8	3	6	4	9	4
9	9	1	2	6	3	4	8	1
1	6	1	4	2	8	9	2	8
6	2	8	3	1	4	1	7	3
1	4	7	7	8	9	2	6	1
9	3	6	5	6	1	8	1	2

SOLUTIONS

Q1) UK album sales (60k for silver, 100k for gold, 300k to go platinum). Q2) Hijacked. Q3) Three lines. Q4) The 1st, 3rd and 6th. Q5) ALL GOOD THINGS MUST COME TO AN END. Q6) See illustration on p104. Q7) Things that can be 'spung'. Q8) Ignore the spare coin - move one coin from left to right. Using distance x weight, $(7+1) \times 3 = 24 = (5+1) \times 4$.

QUICK QUIZ

How much do you know about Antarctica?

Q1

A team led by which explorer was first to reach the geographic South Pole?

- a) Ernest Shackleton
- b) Robert Falcon Scott
- c) Roald Amundsen

Q2

In which year did the Antarctic Treaty come into force?

- a) 1921
- b) 1941
- c) 1961

Q3

An attempt to drill into which Antarctic lake failed last year?

- a) Vida
- b) Ellsworth
- c) Vostok

Q4

Antarctica contains how much of the world's ice?

- a) 50%
- b) 70%
- c) 90%

Q5

Which of these animals is not found in the Antarctic?

- a) Polar bears
- b) Emperor penguins
- c) Fur seals

Q6

What's the lowest temperature ever recorded in Antarctica?

- a) -49.2°C
- b) -89.2°C
- c) -129.2°C

Q7

What's Antarctica's highest peak?

- a) Vinson Massif
- b) Dome A
- c) Mount Sidley

ANSWERS:

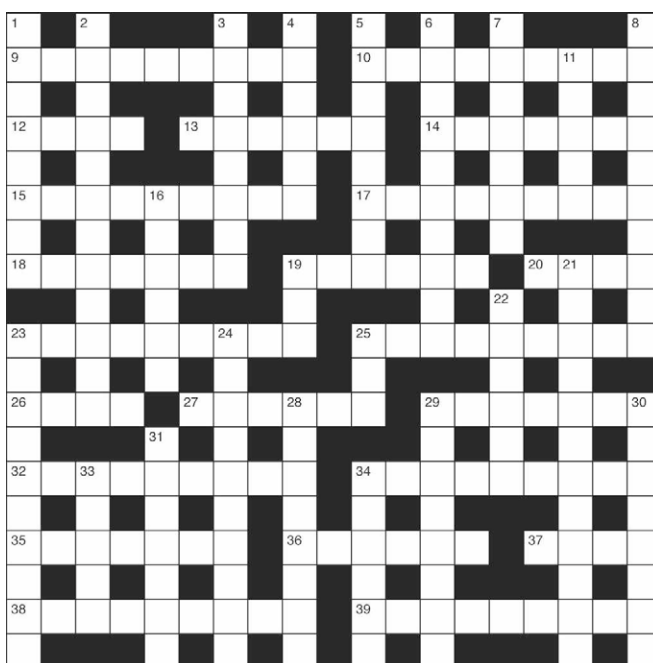
1c, 2c, 3b, 4c, 5a, 6b, 7a

YOU ARE:

- 0-3 Cutting no ice
- 4-5 Skating on thin ice
- 6-7 Vanilla Ice

FOCUS CROSSWORD No 150

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ACROSS

- 9 Outer layer of old, old globe (9)
- 10 Hebrew character gets nothing, or the smallest number (5-4)
- 12 Dreaming about some paper (4)
- 13 Terribly pert, having a new bone-cutter (6)
- 14 Old plane report achieves harmony (7)
- 15 Tooth might stir Cupid into action (9)
- 17 Star has to show protection (9)
- 18 Climbed with daughter and got injured (7)
- 19 Archetype of a victory by a sailor (6)
- 20 Dam is endlessly strange (4)
- 23 Wander to club to see coastal feature (9)
- 25 Fruitlessness as I try tiles out (9)
- 26 Once changed shape (4)
- 27 Sort out graduate getting a cell matrix (6)
- 29 A devil of a writer (7)
- 32 He will have to point robe out at the plant (9)
- 34 Harsh prisoner starts to act like a boa (9)
- 35 Claimed to be working in base ten (7)
- 36 Volunteers to have a rum cocktail in a crisis (6)
- 37 Tuft of wool from some sheep, say (4)
- 38 Loose rein fixed with plant product (9)
- 39 Shape lent grace to another shape (9)

DOWN

- 1 Inflammation ruins tie, sadly (8)
- 2 Giving opposite opinions on north and south (12)
- 3 A pet trod warily, having four legs (8)
- 4 Input device is very important at home (6)
- 5 Finding antacid in a game's wrong (8)
- 6 See agent creep about, but in proportion (10)
- 7 No chips are used in teaching method (7)
- 8 Joules used by 007 making atomic connections (4,6)
- 11 Wear down queen with poem (5)
- 16 Modernise union with taped composition (6)
- 19 Join a religious man (3)
- 21 Wide-ranging complaints in study (12)
- 22 Tragic move, swapping Roundhead for British lion, say (3,3)
- 23 Her odd cane construction had shape (10)
- 24 Prepare toast close to a surgical instrument (10)
- 25 Lose argument about the Baltic, say (3)
- 28 Never too upset to be partial (8)
- 29 Many disc formats used in forceful study (8)
- 30 Fastening arranges personnel (8)
- 31 Land men work in obscurity (7)
- 33 Cruel form of wealth (5)
- 34 Hack works with artist at energy centre (6)

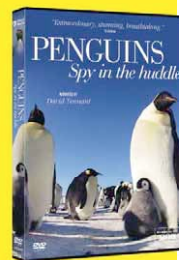
SOLUTION TO CROSSWORD No 147

S Millard, W Pratt, Kathy Humphrey, MN Wesley and Mike McKeown solved issue 251's puzzle and each receive a copy of *This Is Improbable* by Marc Abrahams.



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The first five correct solutions drawn will each win a copy of *Penguins: Spy In The Huddle* on DVD (BBC, £17.99). Entries must be received by 5pm on 2 May 2013. See below for more details.



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INTO THE FUTURE

STEPHEN BAXTER

ROBOTS ARE AN old dream in science fiction, dating back at least as far as Czech writer Karel Capek's 1920 play *R.U.R. (Rossum's Universal Robots)*. This work gave us the term 'robot', based on the Czech for 'serf labour'. But the robots of our future may be less like the carefully controlled humanoid companions of Isaac Asimov stories such as *I, Robot* (1950) than intelligent gadgets and vehicles like those in the 2008 film *Wall-E*.

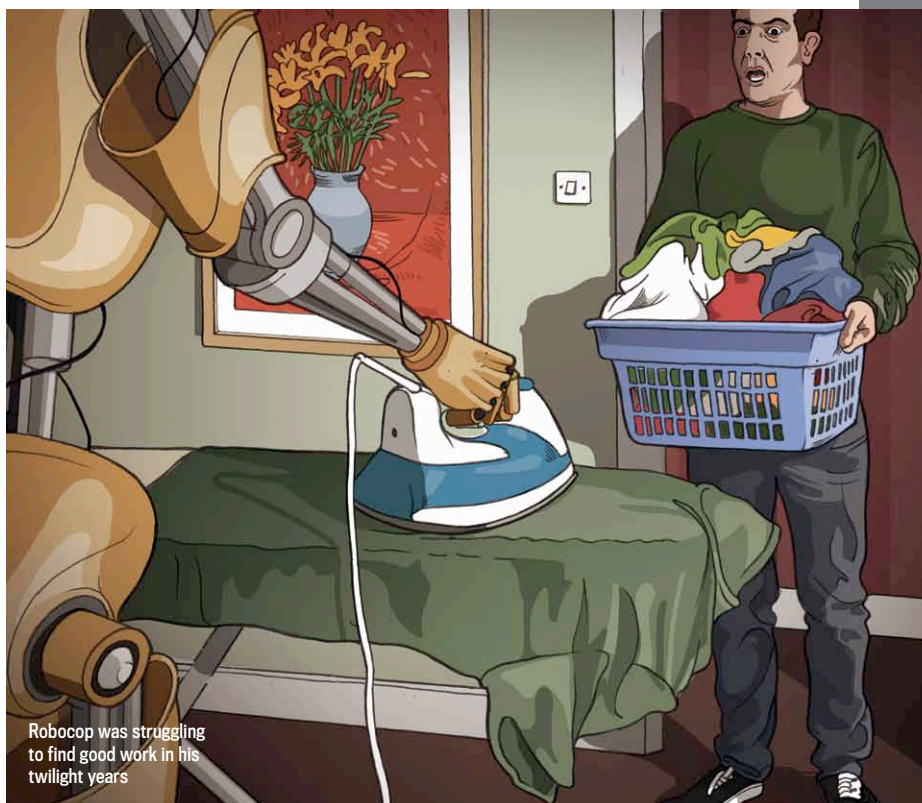
War-making robots are already very much in the news, and manufacturing them has become a highly profitable industry. The US military has led the way in the use of unmanned aerial vehicles, or UAVs: drone aircraft capable of making attacks on enemy positions without threat to human controllers who, unlike the pilots of conventional aircraft, stay far behind enemy lines. There is a drive for the manufacturers to make these robot flyers ever more autonomous: that is, capable of making independent decisions. At present most UAVs rely heavily on human control via radio communications, but this can be disrupted; an independently smart UAV would be less prone to this kind of interference. But critics, such as the International Committee for Robot Arms Control, warn against devolving life and death decisions to robots, if only for fear of conflicts escalating beyond human control.

Meanwhile, the drone technology is being developed for other applications. The University of Warwick is currently developing a UAV capable of mapping the interior of old radioactive silos at Britain's Sellafield nuclear reprocessing plant, thus sparing humans from having to work in such a dangerous environment.

Robots are also taking on hard and dangerous work in other fields. For example, the Rio Tinto company is experimenting with robot vehicles in mines in the Pilbara region of Australia, including driverless trucks the size of three-storey buildings, like a vision from *Avatar*.

Even in more hospitable environments, robots are finding a role. Autonomous farming machines are being developed by groups like the Harper Adams University College in Shropshire. Imagine a self-steering tractor finding its way across a field using GPS, armed with implements like ploughs, sprayers and weeders, and smart, with machines able to talk to each other so that a harvester might call over a trailer when it is ready to unload grain. Our countryside may come to seem alien, covered by geometric grids to suit the robot workers rather than the traditional field patterns of the past.

Space is one area in which robot explorers have led the way since the last human astronaut returned from the Moon in 1972. Currently such robots remain reliant on commands from Earth, and in the near



“Would we have ethical qualms about sending an artificial consciousness into a lethal radioactive environment?”

future this limitation may actually ensure some human presence in space. NASA is considering proposals to send astronauts into orbit around bodies like the moon, Mars and even Saturn's moon Titan, so that they can control robot craft in the atmosphere or on the surface without incurring the long time delays of communications from Earth – because of the finite speed of light, these can be as much as 20 minutes one-way between Earth and Mars, say. But the more challenging and interesting missions will surely require robots capable of decision-making: submarine explorers of the ocean under the ice of Jupiter's moon Europa, or even probes to the stars for whom the communication time delays will be measured in years.

There may be a danger in allowing our robots to become too smart, however. Would we have ethical qualms about sending an artificial consciousness into a lethal radioactive environment, or on a one-way mission to Mars or Jupiter? And would the sheer boredom of drudgery on a farm cause a strike of sentient tractors? Perhaps the robotic rebellion of the future will not be led by *Terminator*-style

warrior robots, as in the movies, but by the much more mundane machines which we will by then have allowed to run our farms, our factories – and our homes. ■

STEPHEN BAXTER is a science fiction writer whose books include the *Destiny's Child* series and *The Science Of Avatar*

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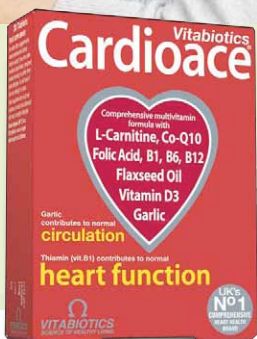
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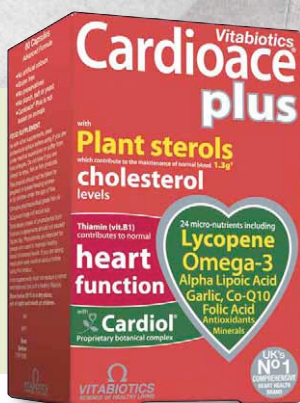
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